TRAFFIC ENGINEERING & CONTROL

OF MICHIGAN
AUG 15

Vol. 3, No. 3, July, 1961 Annual Subscription £2 2s. 0d., Single copies 3s. 6d. monthly

AUTOSTACKER fully automatic parking garage

SOLVES PARKING PROBLEMS

RAPID PARKING AND WITHDRAWAL

BUILT TO ANY CAPACITY ABOVE OR BELOW GROUND

9ft. x 51ft. IS SPACE ENOUG

MAXIMUM DENSITY PARKING

LOWEST CAPITAL COST

ONE MAN OPERATION

ABSOLUTE SECURITY

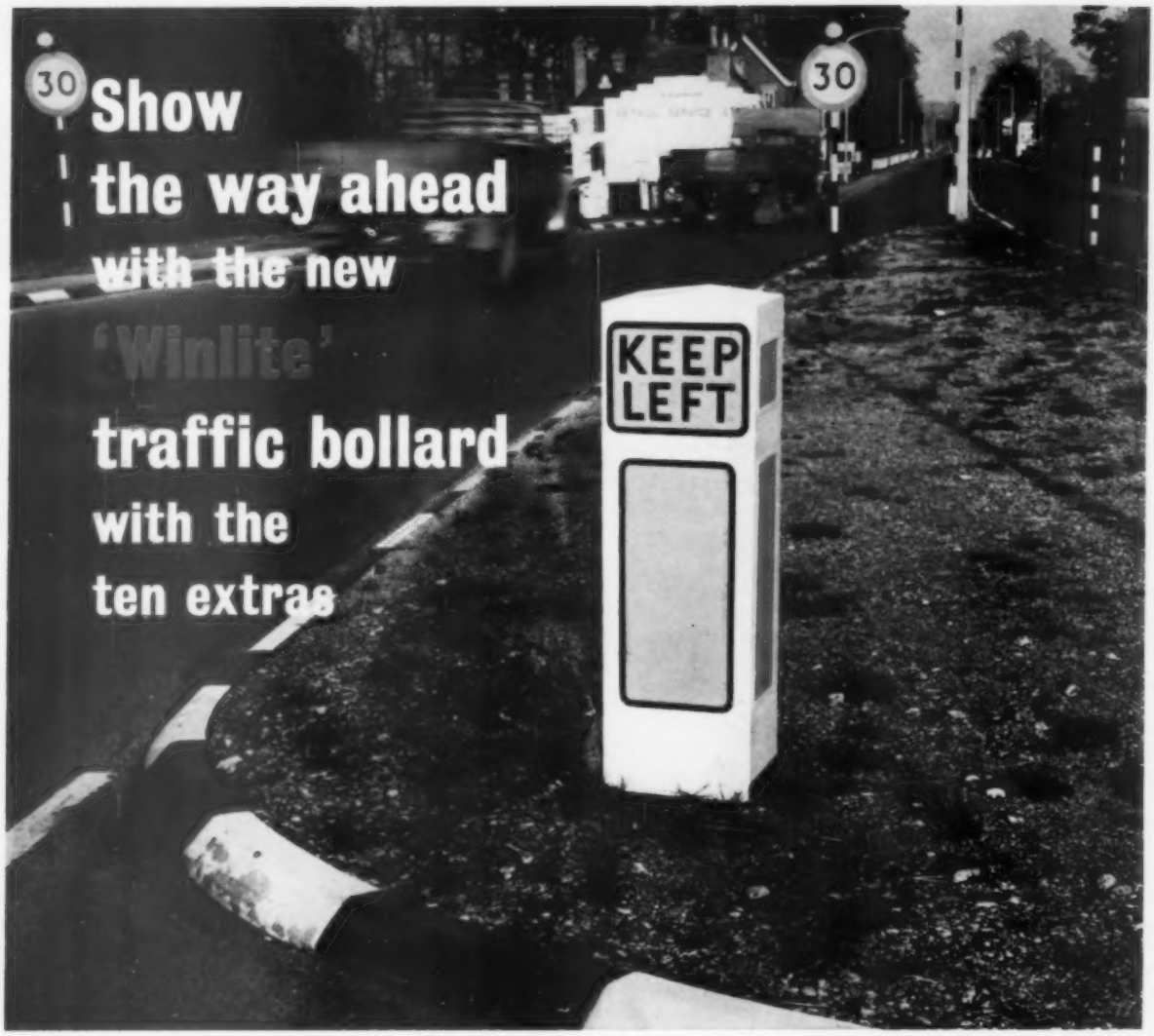
LOW OPERATING COSTS

AUTO-STACKERS LIMITED

20 EASTBOURNE TERRACE - PADDINGTON - LONDON W

Telephone: Paddington

for further information



OUTSTANDING FEATURES

1 *One piece moulding—including translucent panels
2 Shears under impact from base
3 Weight 20 lb.
4 Rustless
5 Easy site maintenance—at low costs
6 *Keep left panel contained IN laminate
7 Panel edging integral with moulding
8 Epoxide coated brackets
9 Door-ribbed, bowed, secured, ensuring maximum rigidity
10 Light, fast colours

*Patent Pending

Unfilled Polyester Resin Reinforced with Glass Fibre

WINSSER SIGNS LTD

STANHOPE ROAD · CAMBERLEY · SURREY Telephone: CAMBERLEY 2723/4/5

TRAFFIC ENGINEERING & CONTROL

Incorporating TRAFFIC MANAGEMENT

VOLUME 3 No. 3 JULY 1961

The only British monthly devoted exclusively to traffic engineering.

Editor
ERNEST DAVIES

Editorial Advisory Board
SIR WILLIAM G. HOLFORD
SIR WILLIAM BLACK
PROF. W. FISHER CASSIE
WILFRID ANDREWS
CHRISTOPHER T. BRUNNER

Editorial Consultants

Lighting
GRANVILLE BERRY

Parking
CONRAD ANDREN

Signs and Markings
K. SUMMERFIELD

Road Safety
BRIG. R. F. E. STONEY

Industrial News Editor
N. A. KELLY

Advertisement Director
ERIC G. DAVIES

Advertisement Manager
A. G. D. SOAMES

Circulation Manager
E. M. CLARKE

Traffic Engineering & Control is published by Printerhall Limited, 34-40 Ludgate Hill, London, E.C.4, City 1755/6/7, and printed at The Grange Press, Southwick, Sussex.

The entire contents are protected by copyright in Great Britain and the Universal Copyright Convention, but matter may be reproduced provided that due acknowledgment is made, except for complete articles, in which case application should be made to the Editor.

Annual Subscription £2. 2s. 0d. post free (single copies 3s. 6d.) United States and Canada $7. All other countries £2. 10s. 0d. sterling.

CONTENTS

Editorial Opinion 151

Topics of the Month 153

FEATURES

Canadian Report—Highway Planning Study, Vancouver . . . 154
P. Long

Traffic Volumes—Journey Times and Speeds by Moving-Observer Method 159
T. E. H. Williams and J. Emmerson

Wrexham's Traffic Study 163
D. M. Craig

Reflectors on Roads with Raised Kerbs 169
A. W. Christie

American Report—Traffic Control Device Manual—(II)—Signals and Islands 172
Burton W. Marsh and William L. Carson

DEVELOPMENTS ILLUSTRATED 176

Traffic Engineering Study Group—Safety Aspects of Motorway Design 178
W. F. Adams

Parking Section—Housing the Motorcar 182
J. L. Womersley

Traffic Symposium—Traffic Design in Urban Areas 183
J. T. Duff

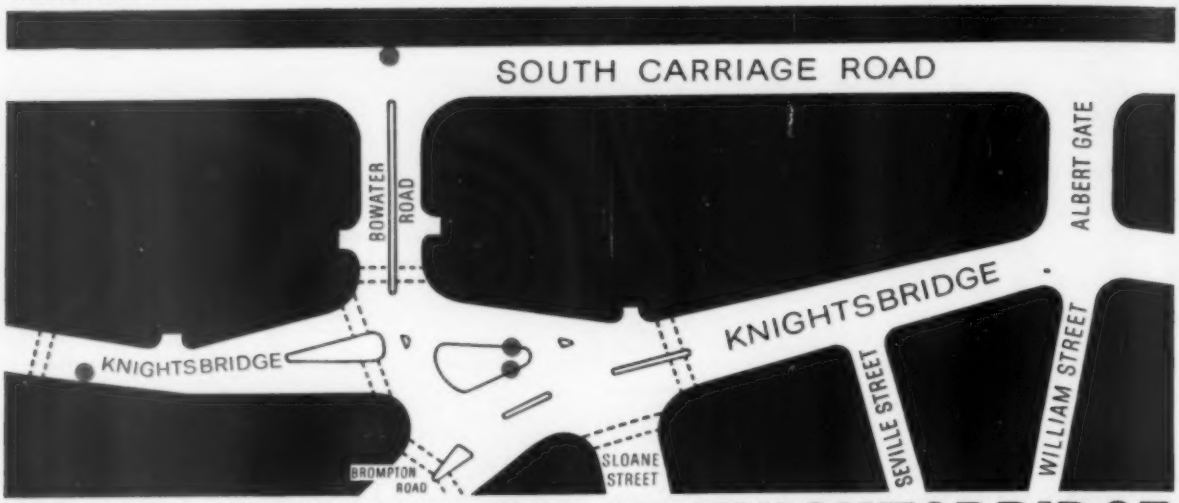
Traffic Control Devices—Signal Maintenance 185

New Publications 187

Lighting Section—Lighting and Road Safety 189
F. Bähler

Industrial News and Information 193

TEC548 for further information



TYPE 54 IN ACTION AT KNIGHTSBRIDGE

With the building of Bowater House, many changes were necessary to the traffic controls in Knightsbridge, Sloane Street, and Brompton Road. The installation of linked systems of signals, Type 54 controlled, ensure the swift and safe flow of traffic.

Type 54 is the most modern method of vehicle-actuated control. It is exceptionally versatile and has a wide variety of facilities besides offering the greatest flexibility in variation, duration and sequence of signals.

For modern traffic conditions—Type 54.

AUTOMATIC TELEPHONE & ELECTRIC CO. LTD. STROWGER HOUSE, ARUNDEL STREET, LONDON, W.C.2. Tel: TEMple Bar 9262

ELECTRO-MATIC
VEHICLE ACTUATED
ROAD SIGNALS
AT 10351

The Roads Programme

IN terms of actual achievement, the recently published report of the Ministry of Transport for the year 1959-60 on 'Roads in England and Wales' at first glance makes impressive reading but, when viewed against the background of need, somewhat less so. Actual payments on new construction and major improvements were £55.73 million and commitments £74.45 million. Expenditure has, of course, steadily mounted since and is estimated at £65 million for 1960-61, £76 million for 1961-62, and £88 million for 1962-63. The course of the roads programme cannot, however, be measured only in terms of expenditure. Authorizations are of even more significance giving, as they do, an indication of work in progress. Here there is cause for concern. In a report on the Government Road Programme, also published last month, the British Road Federation has estimated the total authorizations likely to be outstanding at the end of the current financial year, which reveals there will be less in the pipeline at the end of the year than at its commencement. If the B.R.F. estimates are correct this is most disturbing. It is therefore essential that every resistance be made by the Minister to any cuts in the roads programme the Chancellor may demand in view of the adverse balance of payments.

There is no sign of a continuing deceleration in the rate of growth of motorization. The August 1959 traffic census showed, in terms of estimated vehicle mileage, an overall increase of 12 per cent over the previous year and that for August 1960 showed a far larger increase. When it is borne in mind that new and improved roads generate traffic, it can be questioned whether the roads programme is keeping pace with this increase. Further, since heretofore the Government has tended to concentrate on trunk roads and motorways and less on urban roads in the towns and cities they link and feed into, any adjustment of the balance by the more costly and slower construction in urban areas should be causing a rise rather than a fall in authorizations. The Government has now belatedly accepted the necessity for giving more consideration to urban areas and has increased its allocations to classified roads on the basis of a three-year rolling programme. This is a distinct advance, but the amount involved is still inadequate. In fact, the Minister has estimated that schemes submitted by the local authorities would call for grants averaging twice what he has announced will be available.

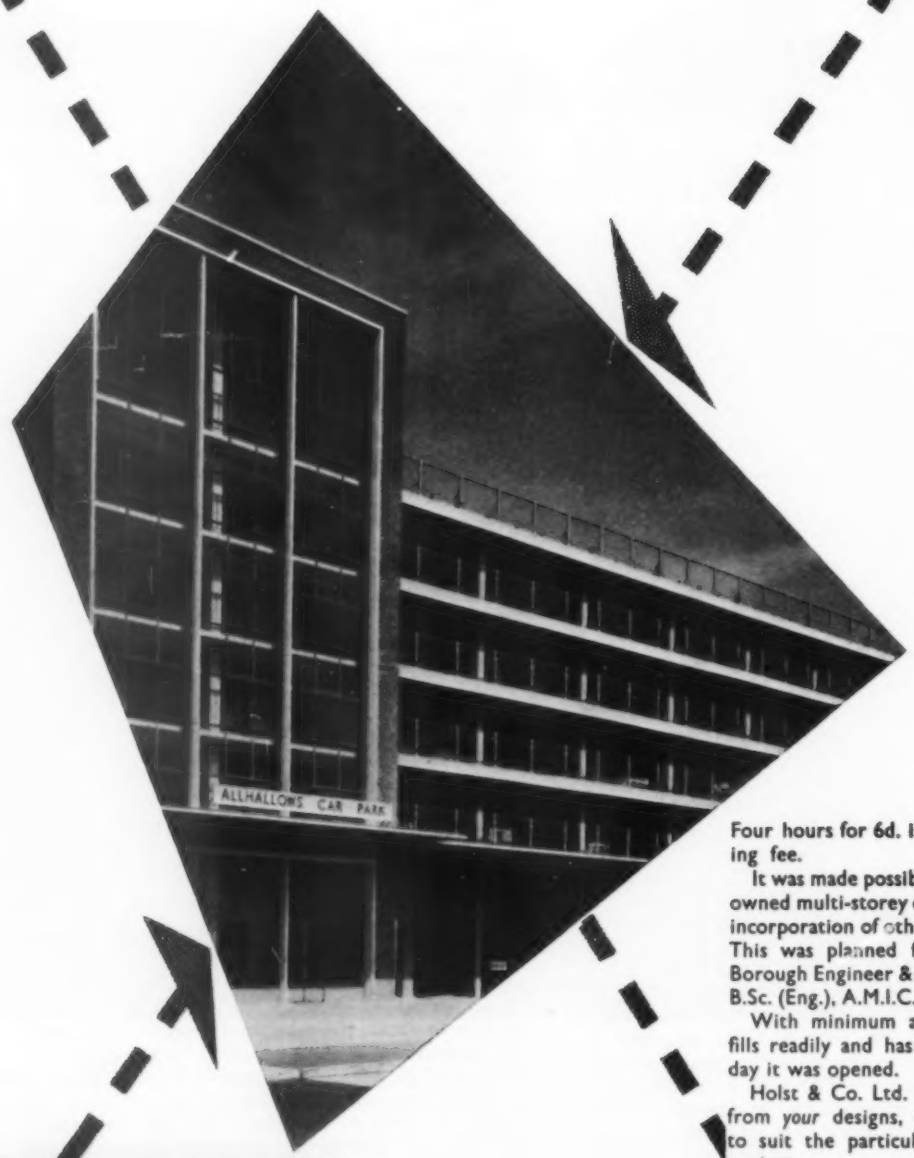
The prospect of traffic congestion in urban areas being relieved substantially and speedily, by the construction of urban motorways or other major improvements, remains poor. This is particularly unfortunate because so many areas are due for redevelopment, schemes are being drawn and funds for commercial development appear to be available. The consequence could be that such urban renewal might take place without sufficient regard for traffic needs and without the guidance on urban traffic planning, in the long-term, which the Ministry should be giving. Full advantage may not therefore be taken of the opportunity for comprehensive planning that now offers. Possibly, some schemes could be facilitated if greater flexibility were permitted as regards land acquisition in the immediate neighbourhood of projected road schemes. Since, by and large, under present legislation acquisitions only required directly for highway purposes attract grant, local authorities are sometimes handicapped financially from proceeding with urban renewal on the scale they would prefer, and which would serve the interests of traffic best and enable greater segregation of traffic and pedestrians, even when, in the long-term, it could be economically justified. The result is that new construction continues far too frequently on a piecemeal basis and urgent schemes can only be undertaken in bits and pieces.

The inadequacy of funds allocated to urban roads makes it more essential than ever that the most be obtained from existing roads by the application of traffic engineering methods to relieve congestion and improve traffic flow, as is now being done in London, on an increasing scale. On this subject, in its report, the Ministry states under the heading 'Traffic Management':

> The provision and maintenance of a road system does not, of itself, ensure that it will be used to the best effect. The proper use of roads is a function of Traffic Management and the application of effective regulations and flow-control techniques is becoming increasingly necessary, with the growth of traffic, not only in towns and city centres but also on the open road.

'Traffic Management' is a new description recently adopted by the Ministry because it considers it wider than traffic engineering. It should not, however, be allowed to supersede the earlier terminology, because to obtain the maximum capacity from roads the methods and techniques of the engineer, as well as those of the manager, need to be applied, not only to geometric design but also to the regulation and control of traffic flow. Many of the branches of civil and highway engineering, electrical and mechanical included, are employed by the traffic engineer. Traffic management is, therefore, equally too narrow a term, but both are expressive and they should be regarded as complementary. For this reason, the newer term has been adopted for incorporation on our title page but as subsidary to the original title of this Journal.

4 hours for 6d !



Four hours for 6d. is a remarkably low parking fee.

It was made possible in the new municipally owned multi-storey car park at Bedford by the incorporation of other services such as shops. This was planned from the outset by the Borough Engineer & Surveyor, F. W. Dawkes, B.Sc. (Eng.), A.M.I.C.E., M.I.Mun.E., A.M.T.P.I.

With minimum attendance this car park fills readily and has run smoothly since the day it was opened.

Holst & Co. Ltd. are pleased to construct from *your* designs, or to create structures to suit the particular requirements of any project.

HOLST

46 CLARENDON ROAD • WATFORD • HERTS.

Telephone: **WATFORD 34481**

BIRMINGHAM MANCHESTER LEEDS DURHAM EDINBURGH CARDIFF

Topics of the Month . . .

AT long last the Greater London traffic survey, first announced over a year ago, has been agreed between the Ministry of Transport, the London County Council and the contracted consulting engineers, and the first interviews will take place this summer. Although the survey is not to be as comprehensive as at first proposed by the American consultants, who have been brought in to conduct it, it appears to be on a sufficiently wide scale to provide data on traffic movements in London and on the travel habits of the Londoner, from which it should be possible to make a reasonably reliable projection into the future. The survey will be by both roadside and home interview, supplemented with traffic counts. A 10 per cent sample of vehicles will be taken on the streets, 20 per cent of commercial vehicles will be covered by questionnaires to vehicle operators but only 2 per cent of homes will be interviewed, of which nine out of ten will include car owners. Public transport is to be omitted, but information on its use will be obtained from the home interviews and London Transport Executive data will no doubt be available. Interim information will be obtained, but, unfortunately, it has been decided that any estimation of traffic volumes and consequent needs some 10 to 20 years ahead will have to await the final analysis and this is unlikely to be ready until 1963.

It is claimed that this is the largest survey ever undertaken. That may be so as regards the area to be covered, some 900 square miles, but its extent is not as great as for instance, the Chicago Area Transportation Study, which has collected a vast amount of detail that the London survey will not provide. This is particularly so as concerns land use, without full knowledge of which any projection cannot be fully reliable. Much information on this is available, however, in connection with development plans. Because this is the first major survey of its kind to be conducted, it was wise to draw on America's greater experience and Freeman, Fox and Partners, the consultants with whom the LCC have contracted for the survey, have called in to conduct the survey the American consulting firm, the Engineering Service Corporation, who are making use of the services of one of America's most experienced traffic engineers in this field, Mr. Wilbur Smith.

Municipal Engineers in Conference

ALTHOUGH the papers presented at the Annual Conference of the Institution of Municipal Engineers, held at Brighton June 13 to 17, covered many of the varied duties and responsibilities of the municipal engineer, the over-riding necessity for the all-purpose authority to provide for modern traffic requirements was repeatedly to the fore. In fact, one speaker suggested that redevelopment plans would be judged by future generations by the way in which they coped with the motor vehicle in movement and at rest. While there was no unanimity of view as to how traffic needs could best be met, it was clear that the emerging view favours many of the newer projects that are becoming increasingly accepted by the more advanced authorities, including establishment of pedestrian precincts, mandatory provision of off-street servicing and parking facilities, grade separation of traffic and limited access urban motorways to act as distributor roads. Because ring roads, on original ministerial guidance, have long been included in many of the plans for urban redevelopment, they still appear to be the most favoured, and perhaps insufficient consideration is being given to such alternatives as tangential and radial roads. There was, however, a welcome appreciation of the fact that the motor vehicle not only brings business to the towns but is more often than not headed for them and is, therefore, not by-passable and that restriction on its use can be detrimental to the economic and social life of the town.

For the first time the International Federation of Municipal Engineers participated in the Conference and the discussions that arose on the paper by Ir. J. A. C. Tillema, Director General of Public Works in Rotterdam, on Municipal Engineering in the Low Countries, and on the paper presented by Mr. P. V. Marchant, the Borough Engineer of Wandsworth on 'The Municipal Engineer and his Future', revealed that there is not always complete acceptance of the necessity for teamwork on the part of all professions concerned in the planning, designing and execution of urban redevelopment projects.

Meeting of Traffic Engineers

THE World Traffic Engineering Conference, assembling in Washington next month, is attracting considerable international support. Whereas some 700 members of the Institute of Traffic Engineers will meet for their annual conference, August 21 to 22, they are to be joined by well over a hundred from Western Europe for the international sessions, August 23 to 26. An opportunity thus arises for sharing experience and know-how which should prove of particular value to those European countries which are newer in the field. This linking of American and European traffic engineering is of importance because this comparatively new branch of engineering has not been developing entirely along the same lines and it would be of advantage if a common definition could be reached on both the function of the traffic engineer and on the scope and lines of demarcation of traffic engineering. Whereas, in its earlier days, traffic engineering developed in America essentially as the regulation and control of traffic, and later quickly extended to the scientific collection and analysis of traffic data, only recently has it embraced the more comprehensive field covered by traffic engineering in Europe, including participation in the planning and design of the whole roads and traffic network, in collaboration with the other professions concerned. Further, since in this country traffic engineering has developed as part of civil engineering, the traffic engineer has been required to be a qualified civil engineer and has no accepted status of his own. This is not so in America where he is recognized in his own right and consequently enjoys a far higher status. Participation in the meeting of the Institute of Traffic Engineers should reveal this difference and may give added interest to the Conference and lead visiting traffic engineers to learn to their advantage from the American example.

Canadian Report

HIGHWAY PLANNING STUDY VANCOUVER

by Peter Long

City Engineering Department

Fig. 1. Oak Street Bridge showing on and off ramps. (By courtesy of the Government of British Columbia.)

VANCOUVER is a young city but has grown rapidly and is the third largest city in Canada with a metropolitan population of 660,000 spread over some 300 square miles. It has a strategic position as a seaport and is the western terminus of two transcontinental railways. The land was first settled about 1870, most of the area was sold within 20 years, and much of it subdivided, often on paper only and without any reference to topography. There is, therefore, a street system laid out basically on a grid pattern with no reference to grades and many jogs in street alignment at the boundaries of different subdivisions.

Since the Second World War the increase in motor vehicle travel has been accommodated largely by widening the carriageways on existing major streets. However, this possibility is limited and the rate of increase of motorization is continuing. In 1953, the Technical Committee for Metropolitan Highway Planning was set up. Because of the urgent need for some water crossings in the area, interim reports on some of these were produced but the study as a whole was divided into two parts:

Part I—Surveys.

Part II—Forecasts and Recommended Plan.

In order to assess the adequacy of the existing arterial street system to serve the present and future vehicular and person movements efficiently, a comprehensive knowledge of present and future travel patterns is required. Since travel patterns are largely dependent on land use, data on present land use and estimated future growth together provide the future travel pattern.

The Surveys undertaken were divided into three sections:

(*a*) Traffic Counts.

(*b*) Origin-Destination Survey.

(*c*) Land Use Inventory.

Counts during the evening rush hours were made at all intersections of arterial streets. At that time no regular programme had been established throughout the area and the assistance of high school students was enlisted. Within the central area of the City of Vancouver, a large amount of traffic count data had already been collected by the Traffic Division of the Vancouver Engineering Department and this information was used for the survey. Screen-line counts using automatic traffic counters were also made. The screen-lines were used to sub-divide the study area for analysis purposes. Because of the topography of the area, obvious and useful screen-lines were the water crossings between the peninsula on which the City of Vancouver is situated and the surrounding areas. Other screen-lines were set up around the Vancouver downtown area (also a peninsula), a north-south line across the centre of the Burrard Peninsula, and along the North Arm of the Fraser River.

Origin-Destination Survey

The O. and D. survey was designed to record the person and vehicular trips from place to place, and the information required was the type and purpose of the trip and its origin and destination. The area was divided into traffic districts, subdivided into

smaller traffic zones, to simplify summarizing the trips. The different districts varied considerably in size, depending on the intensity of development, but generally the zones included a population of about 2,000 persons. The complete survey consisted of interviews with drivers on the existing crossings of the South Arm of the Fraser River; a questionnaire card survey of driver and passengers, and bus and ferry passengers crossing Burrard Inlet; a telephone interview of a sample of the registered owners of motor vehicles in the area; and a questionnaire card survey of bus passengers. The data for each trip was coded and transferred to punch cards. The survey revealed 130,000 motor vehicles in the area, about 98,000 of which made trips on any particular weekday. The total trips per day generated by these vehicles was 690,000, or about 900,000 person trips by motor vehicle. The information was compared with the volumes recorded in the screen-line checks. The volumes derived from the O. and D. survey ranged from 81.2 per cent to 93.2 per cent of the volumes actually counted with an average of 87 per cent. This degree of accuracy was considered satisfactory.

Land Use Inventory

Since travel and land are interrelated, a forecast of future land use can be used to forecast future traffic. The degree to which an area attracts or generates traffic depends on the type and intensity of land use in the area. Existing land use reflects travel patterns and provides a basis for estimating the generation of trips by various types of land use. The acreages of major land uses were tabulated for the 365 traffic zones. Sixteen main classifications were used, including various types of residential, commercial, industrial use, etc. Much of the data was recorded from assessors records, fire underwriters maps, and air photographs.

Travel Analysis and Forecast

Motor vehicle travel between traffic districts is a function of trip generation of the districts and the travel times and distance between them. The existing relationships, with some adjustments, can be applied to future population and land use forecasts to predict the trip generation and the future travel pattern. For public transport it was found that the person trip generation is related to population density, vehicle ownership per capita and distance from the Central Business District (C.B.D.).

The total potential land use of the metropolitan area was estimated. The population associated with

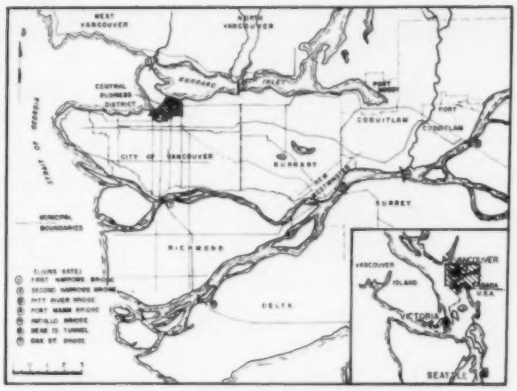


Fig. 2. Key plan showing the general lay-out of the Vancouver area. Inset shows the City in relation to the Pacific coast.

such development was estimated and referred to as the 'horizon population'. This horizon forecast was for a two million population, and was used in assessing the distribution of the 1976 population. The forecast 1976 metropolitan population was determined from the national and provincial estimates. It was assumed that 47 to 48 per cent of the provincial population would live in the metropolitan area: this figure has been constant for 30 to 35 years. The 1976 population forecast for the metropolitan area was 1,241,000. The distribution of 1976 population by traffic districts was estimated from the existing population distribution, growth trends, horizon year population and the influence of new highways on the relative convenience of access. Re-development projects were also considered.

Motor vehicle ownership was 0.24 vehicles per capita in 1955. On the basis of past trends, motor vehicle ownership was forecast to be 0.334 vehicles per capita by 1976. Forecasts were made of the industrial work force, the total commercial floor area, and the distribution of each of these. With the predicted population, motor vehicle ownership and land use, trip generation of each of the 80 traffic districts was calculated for 1976, together with the distribution of travel between the traffic districts.

Public Transport Forecasts

Person trips by public transport were predicted from the same population and vehicle ownership data above, and the number of person trips per capita was estimated. It was assumed that the relative travel times (and attractiveness) of public transport and

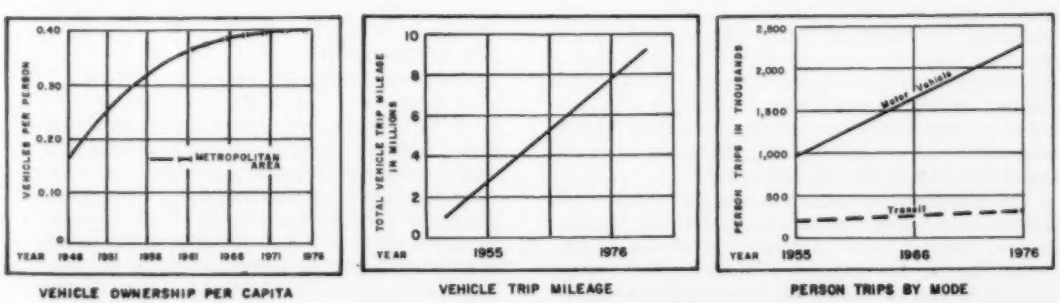


Fig. 3. Diagrams showing the main factors contributing to increased travel, from which forecasts can be made as to its future growth.

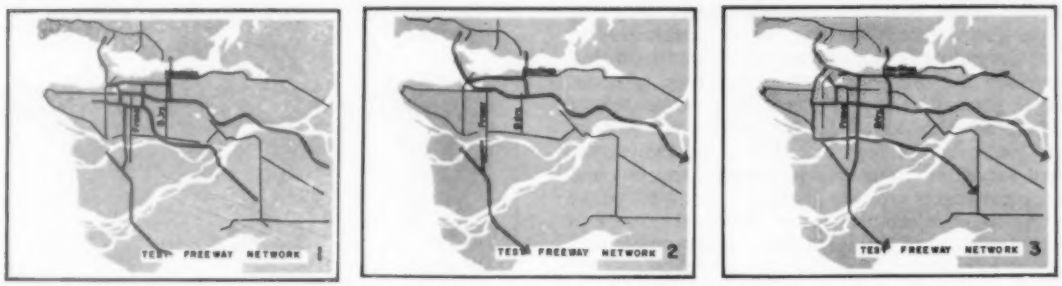


Fig. 4. The first three test networks, following the analysis of which the recommended network was developed.

motor vehicle trips would remain the same over the forecast period.

Existing Street System

The first step in any assessment is to gauge the capacity of the existing street system. The existing system represents a large investment and, therefore, the best use should be made of existing facilities. In general, as traffic volumes on the street grow, they can be accommodated by providing more carriageway which is usually the cheapest way of providing extra capacity. Limit is reached when further carriageway widening would require the acquisition of property fronting on the street. Then the various alternatives for providing extra street capacity must be considered. The existing system was assessed as if all the major streets were paved to full width (e.g. four lanes on a 66 ft. allowance). To assess the deficiencies which would exist in the street system with the predicted traffic, a grid line analysis was made. The area was divided into a one mile grid. The capacity of the major streets crossing the grid lines was calculated using a modification of the Highway Capacity Manual method. The capacity across each grid line segment was compared with the predicted 1976 O. and D. demand resulting in a surplus or deficiency. For concentrated loads at water crossings the allocated traffic was compared with the capacity. The results of the grid line analysis were evaluated to eliminate local effects. The grid line analysis supplemented with some screen line studies showed an area of intense deficiency south-eastward from the Vancouver C.B.D. and deficiences on some bridges.

These deficiencies in the arterial street system can only be met by freeways. Basic assumptions in the study were that there would be little change in weekday travel habits and that motor vehicles and public transport would continue to be the primary modes of transportation. Shorter hours might affect the time but not the intensity of the rush hour, special measures like staggered hours were not considered feasible. Novel forms of transport were not relied on for a solution and it was not considered that innovations would significantly affect the mode of travel over the 20-year forecast period.

The major streets were found to be grossly overloaded in some areas, but widening the existing major streets, beyond their present right-of-way width, would be far too expensive because of the large amount of commercial development along the streets. Adding new major streets between the existing ones would not be workable from a traffic point of view because of the large number of intersections, and would be very undesirable from a land use viewpoint because the new street would disrupt neighbourhood areas. Freeways were the only answer.

Several criteria were used in planning the freeway network:

1. The freeways must eliminate the deficiencies from the major street system.
2. The freeway system must not be so elaborate as to reduce the use of the major streets to a low level.
3. Practical design to provide for predicted traffic volumes must be feasible.

Traffic was assigned to three test freeway networks. The assignments, together with a grid line analysis of the remaining traffic on the grade street system, were evaluated to develop the best network.

In the metropolitan Vancouver area the cities of Vancouver and New Westminster are responsible for their own highways and the Provincial Government for the highways in the other municipalities. Water crossings between two municipalities are also the responsibility of the Provincial Government.

At the time of the study the Provincial Government was constructing the Peace Arch Highway to the United States, which crosses the Fraser River via the Deas Island Tunnel and continues across the Oak Street Bridge to the City of Vancouver. The Trans-Canada Highway was in the planning stage at the time of the study, and it is now under construction. A political decision was taken that the designated route of the Trans-Canada Highway should by-pass the City of Vancouver via the Second Narrows Bridge across Burrard Inlet. The Trans-Canada Highway from the east crosses the Fraser River via the Port Mann Bridge and continues westward, at freeway standard, to the eastern part of the City of Vancouver, where it is continued as a major street to the Second Narrows Bridge.

The Freeway Plan

It was clear that the freeway system should connect with these Provincial highways under construction or in the design stage. The existing neighbourhood areas, re-development plans, existing and proposed zoning were considered in developing the routes, as were topography and construction costs. The broad picture of deficiencies shown by the grid line analysis governed the system and the areas of the City where the freeways were proposed.

Routes suggested for networks were checked for construction cost, economy, and land use. Three networks were tested. The networks were designed

on the basis of judgment, local knowledge, and the grid line analysis. Network 1 was intended to be adequate but not over-elaborate; Network 2 was to be a minimum system and less extensive than Network 1, and Network 3 was fairly extensive with some changes in concept and route location from Network 1. The three networks were tested by estimating the probable traffic loads on each freeway section and ramp, and the residual traffic on the major street. The freeway loads were estimated by traffic assignments and the major street traffic by grid line analyses. The geometric design of the facilities, which would be required to carry the assigned loads, was also considered in the evaluation.

Traffic Assignment

The traffic assignment was to estimate the number of vehicles which would tend to travel on the proposed freeway routes rather than on major street routes. The diversion from major streets to freeways varies with several factors including time, distance, comfort, convenience, costs, and safety. Normally, the most significant factors to a driver are time and distance. These factors are fairly easy to measure in comparing different routes. Studies carried out in Detroit developed a family of curves for percent freeway use versus distance ratio for various speed ratios. The distance ratio is the distance via the freeway route (including the grade street sections at the termini) divided by the distance via the route wholly on grade streets. The speed ratio is the average speed of the trip via the freeway route divided by the average speed of the trip via the grade street route. The distance ratios were calculated from distances scaled off a map. The speed ratio calculations were simplified by assuming a constant ratio between freeway speed and grade street speeds of two to one. The trip information was punched on to cards and processed with the aid of I.B.M. 604 machine belonging to the B.C. Electric Company. The grid line analysis was carried out on the University of British Columbia's digital computer ALWAC III E and compared the O. and D. volumes with the practical capacities of the street system.

The evaluation developed a recommended freeway network connecting with the Provincial Government highways with reasonable freeway loads and grade street loads. No firm decision on the location of a north-south freeway was made in the evaluation of the first three test networks. An alternative location for this freeway was, therefore, tested with the remainder of the recommended system in a further assignment and grid line analysis. No detailed designs were made but typical freeway cross sections, interchanges and access points were assumed at an approximate cost for the whole system of $340 million. This figure included the acquisition of rights-of-way.

Public Transport

The Committee was emphatic that neither public transport nor private motor vehicles are independent but are part of an overall transport system. Public transport is most suited to serve travel between high density areas. In the Vancouver area it will cater primarily for worker and shopper trips and will be largely radial from the C.B.D. Several types of rapid transit systems were considered, including supported rail (conventional), suspended rail, freeway buses,

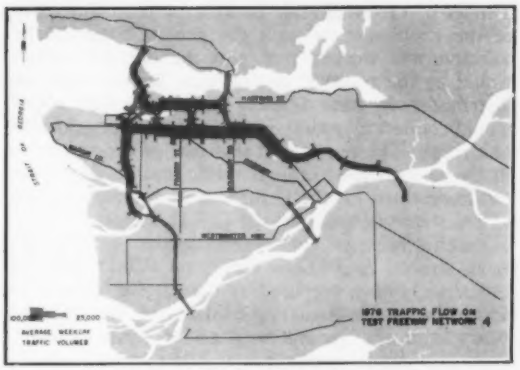


Fig. 5. The recommended network with the traffic assignment shown.

continuous conveyer cars or belts, helicopters, and some other systems. Of all these, an initial appraisal showed only supported rail, suspended rail, or freeway bus systems were worth considering in detail.

The three systems were considered for travel time, convenience, capital cost, operating cost, comfort, safety, and public acceptance. Overall travel time would be fairly similar for the three systems, the differences depending on the method of travel from home to the rapid transit line. Rail systems required transfer which could be eliminated with some types of freeway bus service combined with local service. Freeway bus service can be introduced progressively as freeways are constructed and are generally rated more convenient than either rail system. The capital cost of a freeway bus system would be less than either rail system although, because of relatively large manpower requirements, operating costs would be higher. Operating costs depend largely on the degree of automation of each system.

Rail systems are probably more comfortable than buses with perhaps fewer more serious accidents. Public opinion would probably favour the glamorous monorail followed by supported rail. The prestige of a freeway bus system might depend on the operating speeds attained. In the C.B.D. a subway would be more acceptable than an elevated structure, but in the suburbs a freeway bus system is probably best from an aesthetic point of view.

Most operators consider that each route of a rail rapid system must have a potential of 30 to 40,000 passengers in the peak hour for a supported system or 25 to 35,000 for a suspended system. The maximum potential forecast on any route in the metro area is 12,600 passengers per hour over a distance of up to four miles. Beyond this point and on other routes some other form of service, e.g. freeway bus, would be required. Facilities in the C.B.D. for the freeway buses on other routes would be required in addition to rail facilities. A freeway bus system was a clear choice for the Vancouver area. If the staging of freeway construction is such that congestion occurs on freeway sections separate facilities should be provided for the freeway bus to maintain the standard of service and patronage.

Central Business District

The downtown peninsula includes the central business district and the high density apartment

district of the west end. Because of the complexity of the problem here only the general form of the solution was worked out, and the detailed design would be the result of an extensive further study. A distributor by-pass freeway was proposed which would connect all radial freeways with a very close-in belt route. The purpose of this part of the system is to by-pass all the through traffic and to distribute traffic destined for the C.B.D. to minimize, as much as possible, the traffic on the C.B.D. streets.

Parking must be considered together with downtown streets. A previous report on C.B.D. parking had already been prepared by the City of Vancouver and this was brought up-to-date for the freeway study, and the general location of future parking areas, for both short-term and long-term parkers, was determined. Several schemes of transit terminal and distributor were examined for the C.B.D. but further study will be required to decide on the best.

Stage Development

The forecast year for the study was 1976. In the latter stages of the study, in 1958 and 1959, the Peace Arch Highway was being built and the Trans-Canada Highway designed. A further study of the recommended 1976 network was made to determine priorities for the 1976 network. A grid line analysis of the grade street situation was made for the year 1966 together with an analysis of the bridges and tunnel. The O. and D. survey for 1966 was obtained by taking a constant proportion of the difference between the 1955 O. and D. and the 1976 O. and D. and adding this to the 1955 O. and D.

The grid line analysis showed large deficiencies through eastern Vancouver, across First Narrows and the North Arm of the Fraser River. The total cost of relieving all of these deficiencies was too large a proportion of the cost of the whole system to spend in the first eight years. The deficiencies were analysed further to find those most pressing. The First Narrows crossing was overloaded even in 1958 and another bridge or tunnel was immediately required. To relieve congestion on the downtown streets, and to permit desired development of the C.B.D., the distributor by-pass was included. Some connection was required between the freeway Trans-Canada Highway, which stopped short near the Vancouver boundary, and the distributor by-pass. A comparison of costs and benefits of routes to the east, obtained by combining parts of the recommended system, showed the most northerly east-west route to be of most benefit in the early stage. The cost of the first stage was estimated at $160 million.

Conclusion

After the report was submitted in 1959 no action was taken by either the Provincial Government or the municipal governments. It was generally considered that the existing revenues were not large enough to finance the system. In May 1960, the Technical Committee was re-convened to draw up the terms of reference and to select consultants to conduct a financial feasibility study of the first stage of the freeway system. The consultants were to look particularly into the possibility of levying some form of user taxes on the system either by means of tolls or some other method. The consultants' proposal for the study is at present before the various governments involved.

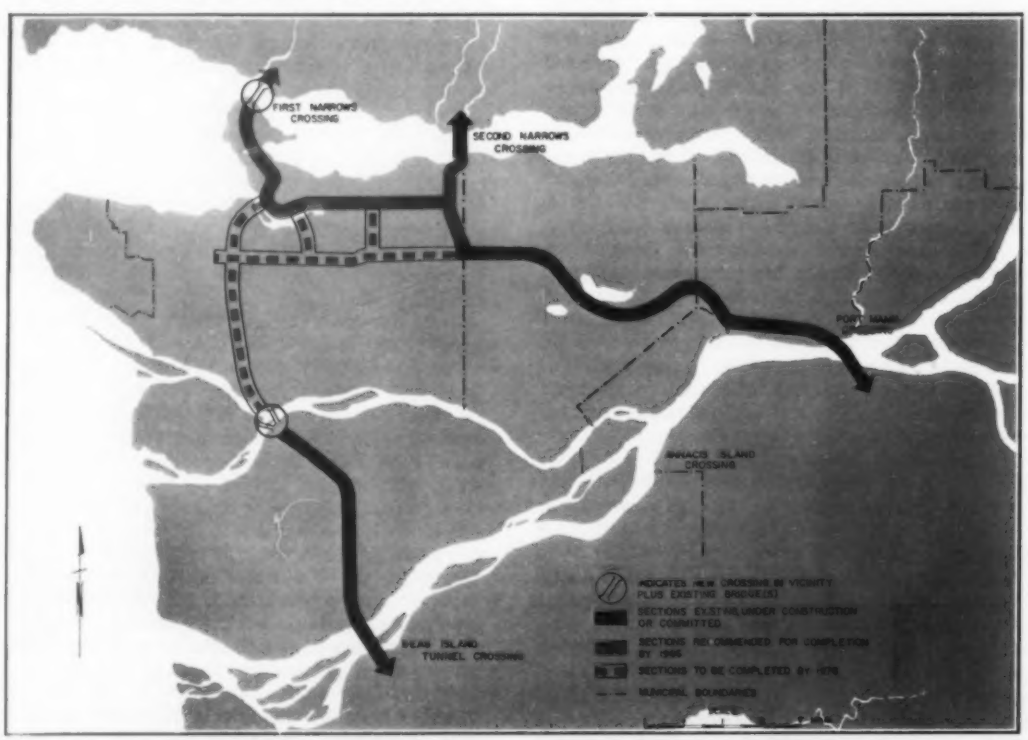


Fig. 6. The recommended system as finally adopted incorporating the programme development stages.

TRAFFIC VOLUMES

JOURNEY TIMES and SPEEDS

by MOVING–OBSERVER METHOD

by

T. E. H. WILLIAMS, *M.Sc., Ph.D., A.M.I.C.E., A.M.I.Struct.E., M.I.H.E.*

and

J. EMMERSON, *B.Sc., A.M.I.Mun.E.*

Dr. Williams is Rees Jeffreys Reader in Highway and Traffic Engineering, Department of Civil Engineering, King's College, Newcastle upon Tyne, in the University of Durham. Mr. Emmerson holds a Rees Jeffreys Postgraduate Award at the College.

THIS paper gives the results of field experiments carried out in Newcastle upon Tyne to determine the influence of the number and duration of test runs on the accuracy of estimates of traffic volumes and journey times, as given by the moving-observer method. It was proved:

(1) With a constant level of traffic flow, the degree of accuracy of the estimated volume was proportional to the reciprocal of the square root of the total sampling time. The sampling time may be increased either by increasing the numbers or lengths of test runs.

(2) With a constant sampling time, the degree of accuracy of the estimated volume was proportional to the square root of the actual volume.

(3) For journey (travel) times there was a rapid increase in the accuracy of the estimate as the number of runs in one direction increased from one to nine. Increasing the number of test runs in one direction beyond nine produced relatively little increase in accuracy.

History of Method

The moving-observer method was developed by the Road Research Laboratory, Traffic and Safety Division, and was described by Wardrop and Charlesworth in a paper[1] given to the Institution of Civil Engineers in 1954. The method consists of making a series of runs in a test vehicle with and against a traffic stream. The observers in the test vehicle measure and record the following information for each batch of test runs:

(*a*) The mean number of vehicles met while travelling against the traffic stream (M).

(*b*) The mean number of vehicles which overtake the test vehicle while travelling with the traffic stream (O).

(*c*) The mean number of vehicles passed by the test vehicle while travelling with the traffic stream (P).

(*d*) The mean journey (travel) times for the test vehicle when travelling against and with the traffic stream, (T_a and T_w respectively).

For the stream in question, the average rate of flow or volume (Q) of vehicles over the test section for the periods covered by the test runs is given by Equation (1):

$$Q = (M + O - P)/(T_a + T_w) \ldots . (1)$$

The average journey time (T) for all the vehicles in the stream is given by Equation (2):

$$T = T_w - (O-P)/Q \ldots . (2)$$

If the magnitudes of M, O, and P are recorded separately for three groups of vehicles—(a) Cars and light goods, (b) Medium and heavy goods, and (c) Buses—Equations (1) and (2) can be applied to each group to determine its average volume and journey time.

Wardrop and Charlesworth stated that '12 to 16 runs in each direction are usually sufficient to give reasonably consistent estimates of speed and flow'.

In 1956, Wilkie and Gran of the Traffic Engineering Department, Cook County, Illinois, published the results of their tests of the accuracy of the moving-observer method in determining the total traffic volumes during the off-peak period 10.00 a.m. to 3.00 p.m.[2] They concluded that the method gave an unbiased estimate of the five-hour bi-directional traffic volumes, when compared with records obtained from mechanical traffic counters. The two-way flows during the periods of test varied from 240 to 4,490 vehicles per five hours over the grid system of roads concerned. The roads varied in section from a single two-lane carriageway to dual two-lane carriageways. Nine of the test routes were approximately 0.5 miles long. One test route was 0.85 miles long.

The Cook County tests also showed that the degree of statistical accuracy of the estimated volumes could be determined by means of the Poisson distribution. By statistical regression, it was found that the actual Standard Error (S_a) of the five-hour estimated volume, in terms of the Poisson Standard Error (S_p) was given by Equation (3), and the expression for the Poisson Standard Error is given by Equation (4):

$$S_a = 1.245\ S_p - 4 \quad \ldots\ldots\ldots (3)$$

where

$$S_p = 300(Q/T)^{\frac{1}{2}} \quad \ldots\ldots\ldots\ldots (4)$$

where Q = average or mean volume in vehicles per minute,

and T = total sum of T_a and T_w for all runs (minutes).

In 1958, the National Committee on Urban Transportation, U.S.A., recommended the use of the moving-observer method when determining vehicle volumes and journey (travel) times.[3] As a general rule, when calculating volumes they recommended a total sampling time of 30 minutes, and for minor streets, 10 minutes of test runs per mile of road. For a street carrying 3,000 vehicles per day, with a peak hour volume equal to 10 per cent of the 24-hour volume, they state that in two cases out of three, a total of 30 minutes of test runs would yield an estimate of the peak hour which would be within 10 per cent of the true value.

For journey times, the same Committee recommended a check for dispersion of results based on a minimum of six test runs in one direction. Where the data are proved to be too widely scattered it recommended that a further four test runs be executed, to give a total of 10 runs in one direction.

Test Procedure

The tests carried out by the authors in Newcastle upon Tyne were done on three separate lengths of road. The moving-observer method was used to evaluate the average flows and journey times on sections of the West Road, Scotswood Road and Jesmond Road (see Table 1).

The procedure adopted for these tests consisted of running two test vehicles in opposite directions along a chosen route at the same instant in time. The observers moving with traffic stream A recorded the quantities M_b, O_a and P_a. Similarly, the observers moving in the opposite direction with traffic stream B recorded M_a, O_b and P_b. The combination of the two sets of data enabled the evaluation of the average volumes and journey times for the traffic streams A and B. While the test vehicles were being used, stationary observers located at the ends of the test route counted and classified vehicles, recorded their registration numbers and noted the time of passing. Where a junction occurred within the length of test route, a record was kept of the vehicles which entered or left streams A and B.

TABLE I

Details of test routes

Location	*Length of test section (miles)*	*Width between kerbs (ft.)*	*Land use*
West Road	0.59	42	Residential and Shopping
Scotswood Road	1.46	32	Residential and Industrial
Jesmond Road	0.51	34	Residential and Commercial

For the purposes of analysis, the traffic was considered in three separate groups:

(1) Motor cars and light goods vehicles.
(2) Medium and heavy goods vehicles.
(3) Buses and coaches.

The volumes and journey times computed from the results of the moving-observer tests were compared with those recorded by the stationary observers.

Results

Figs. 1, 2 and 3 illustrate the relationship between the values of traffic volumes, journey times and speeds computed by the moving-observer method and the corresponding values measured by stationary observers. Each and every point on these graphs is the average of the results obtained from at least 18 test runs in any one direction.

For volumes (see Table 2) when the true measured maximum two-way flow of mixed vehicles on the West Road was 850 vehicles per hour, the value obtained by the moving-observer method was 880 vehicles per hour, which was within 4 per cent of the true value. Similarly, when the true total flow on Jesmond Road was 803 vehicles per hour the estimated flow was 841 vehicles per hour, a difference of 5 per cent over the true value. Again, when the true total flow on Scotswood Road was 664 vehicles per hour, the estimated flow was 642 vehs. per hr., a difference of 3 per cent below the true value.

Although the estimated two-way volumes of all vehicles were within 3 to 5 per cent of the true volumes, the differences between the estimated and true volumes for the three separate classes of vehicles in each uni-directional stream varied from a deficiency of 12 per cent to an excess of 25 per cent. The measured uni-directional flows of these three classes of vehicles [(a) Cars and light goods, and (b) Medium Heavy commercial vehicles, and (c) Buses] ranged between 40 and 365 vehicles per hour.

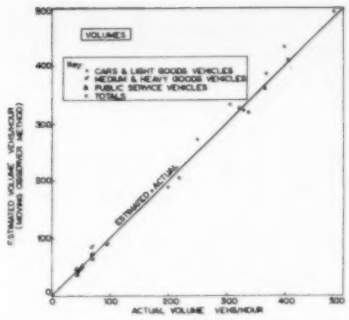


Fig. 1.

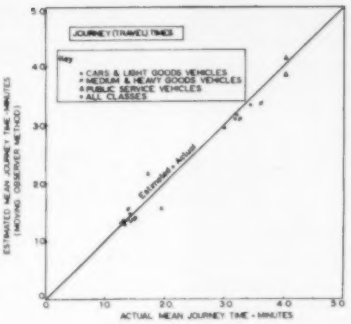


Fig. 2.

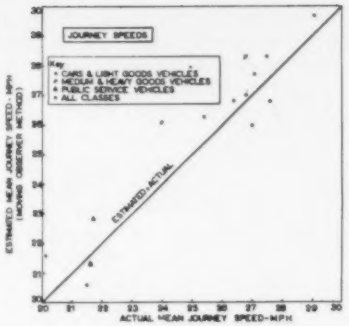

JOURNEY SPEEDS
Key
+ CARS & LIGHT GOODS VEHICLES
✓ MEDIUM & HEAVY GOODS VEHICLES
Δ PUBLIC SERVICE VEHICLES
• ALL CLASSES
ESTIMATED = ACTUAL
ESTIMATED MEAN JOURNEY SPEED - MPH (MOVING OBSERVER METHOD)
ACTUAL MEAN JOURNEY SPEED - M.P.H.

Fig. 3.

The validity of the Poisson statistical distribution at the measured levels of traffic volumes was tested by using the data collected on the three test routes. For each test route, the magnitude of the Standard Error of the Mean Volume was computed for each batch of experimental results (see Note on Standard Error below). Random combinations of the data from individual test runs yielded batches of data of various sizes which were then used to investigate the relationship between Standard Error, Mean Volume and total sampling time.

Fig. 4 shows a graph of the Actual Standard Error (S_a) of the Mean Volume against the product of the Poisson Standard Error (S_p) and a sampling factor (F). Linear regression showed that the relationship between these indices was as given by Equations (5), (6) and (7):

TABLE II

Vehicle Volumes. Comparison of values by stationary and moving-observer methods

Route, Flow and No. of runs	*Class of vehicle**	*Volume (vehs. per hr.)*		
		Stationary Observer	*Moving Observer*	*Difference (%)*
West Road (eastbound) 20 runs	A	365	360	− 1.4
	B	69	86	+24.6
	C	49	48	− 2.0
	Total	483	494	+ 2.3
West Road (westbound) 20 runs	A	249	273	+ 9.6
	B	70	65	− 7.1
	C	48	48	0
	Total	367	386	+ 5.2
Scotswood Rd (eastbound) 18 runs	A	198	190	− 4.0
	B	95	91	− 4.2
	C	43	38	−11.6
	Total	336	319	− 5.1
Scotswood Rd (westbound) 18 runs	A	218	206	− 5.5
	B	68	73	+ 7.4
	C	42	44	+ 4.8
	Total	328	323	− 1.5
Jesmond Rd. (Eastbound) 28 runs	A	322	326	+ 1.2
	B	42	45	+ 7.1
	C	41	38	− 7.3
	Total	405	409	+ 1.0
Jesmond Rd. (westbound) 28 runs	A	305	333	+ 9.2
	B	42	47	+11.9
	C	51	52	+ 2.0
	Total	398	432	+ 8.5

*Class A—Cars and light goods vehicles
Class B—Medium and heavy commercial vehicles
Class C—Buses.

$$S_a = 1.21\ Sp.\ F \quad \ldots\ldots\ldots (5)$$

where $$Sp = (Q/T)^{\frac{1}{2}} \quad \ldots\ldots\ldots\ldots (6)$$

and $$F = (1 - T/D)^{\frac{1}{2}} \quad \ldots\ldots\ldots (7)$$

where Q = Mean Volume in vehicles per minute *over the survey period.*

T = Total sum of T_a and T_w in minutes *for all test runs.*

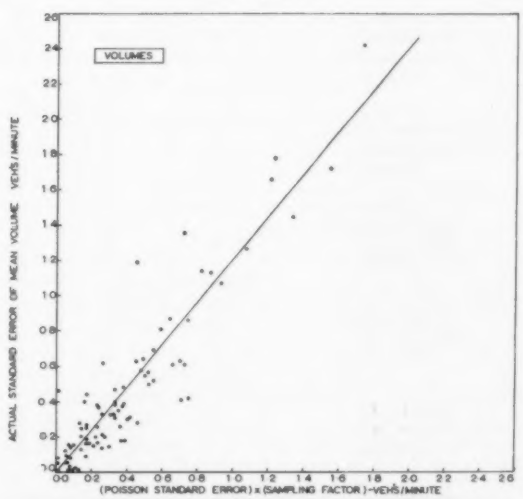
D = Duration of survey in minutes *i.e.*, the time lapse *between the first and last test run.*

The value of the Coefficient of Correlation for this regression was 0.95, which was statistically highly significant. The Poisson mathematical model was therefore proved to be valid for the conditions encountered during the tests in question.

These equations can be applied in practice in the design of programmes of field studies of traffic flows using the moving-observer method, as shown by the example given under Practical Applications (next page).

On the West Road route, only buses in motion were recorded by the moving observer. This resulted in the volumes of buses computed by the moving observer being within zero and —2.0 per cent of the

Fig. 4.



numbers counted by the stationary observers (Table 2).

On Scotswood Road and Jesmond Road, stationary and moving buses were recorded by the moving observer. Their computed volumes were within —11.6 per cent and +4.8 per cent of those counted by the stationary observers.

Table 3 gives the results for journey times and speeds. For Scotswood Road and Jesmond Road the differences between the estimates by moving and stationary observer of journey times and speeds were greater for individual classes of vehicle than for all the vehicles in classes A, B and C. The greatest differences, +26.2 per cent for journey times and +22.6 per cent for speed, occurred in class C when the total sample of registration numbers was small. With the exception of class C, all estimates of journey times and speeds by the moving observer method were within 11 per cent of the values computed by the stationary observers. No results are tabulated for class C vehicles on the West Road because they were not strictly comparable for the reason that only buses in motion were noted by the moving observers.

Fig. 5 relates to the journey times for the traffic on West Road, Scotswood Road and Jesmond Road. It shows the values of the Standard Error of the Mean of each group of journey times plotted against the number of test runs in that group. Each point on the graph relates to a group of runs in one direction only. The general asymptotic form of this envelope diagram illustrates the effect of reducing the Standard Error of the estimated journey time by increasing the number of test runs. There was a rapid increase in the degree of accuracy of the estimate as the number of test runs increased from one to nine. Increasing the number of test runs in each direction beyond nine

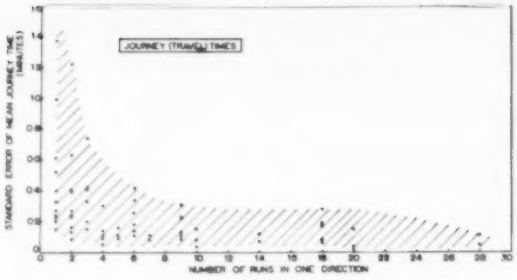


Fig. 5.

produced relatively little increase in accuracy. It is therefore apparent that for a range of traffic flows and lengths and widths of road similar to those met in the Newcastle studies, the minimum number of runs in one direction in any group of test observations should be nine.

Practical Application

In planning a programme of traffic studies by the moving-observer method, Equations 5, 6 and 7 can be combined with the minimum requirement of nine runs in any one direction (Fig. 5) to estimate the probable degree of accuracy of the results which would be obtained for a particular sampling time. For any one hour on a specific day, we have an upper limit of 60 minutes of sampling time. Also, we have the condition that the total sampling time is equal to the product of the number of runs, length of test route and the mean rate of motion of the test vehicle.

As an example, consider a given test route of length 0.50 ml. where it is required to know the magnitude

Concluded on page 168

TABLE III

VEHICLE JOURNEY (TRAVEL) TIMES AND SPEEDS

Comparison of values by stationary and moving-observer methods

Route, Flow and No. of Runs	*Class of Veh.*	*Sample Size, Stat. Observ. (Reg. No.)*	*Journey Time (minutes)*			*Speed (mph)*		
			Stationary Observer	*Moving Observer*	*Diff. %*	*Stationary Observer*	*Moving Observer*	*Diff. %*
West Road (Eastbound) 20 runs	A	117	1.32	1.31	− 0.8	26.8	27.0	+ 0.7
	B	18	1.42	1.34	− 5.6	24.9	26.4	+ 6.0
	A & B	135	1.34	1.32	− 1.5	26.4	26.8	+ 1.5
West Road (Westbound) 20 runs	A	136	1.28	1.32	+ 3.1	27.6	26.8	− 2.9
	B	43	1.40	1.55	+10.7	25.3	22.8	− 9.9
	A & B	179	1.31	1.36	+ 3.8	27.0	26.0	− 3.7
Scotswood Road (Eastbound) 18 runs	A	129	3.22	3.15	− 2.2	27.2	27.8	+ 2.2
	B	68	3.63	3.35	− 7.7	24.1	26.1	+ 8.3
	C	42	4.04	4.10	+ 1.5	21.7	21.4	− 1.4
	A, B & C	239	3.44	3.32	− 3.5	25.5	26.4	+ 3.5
Scotswood Road (Westbound) 18 runs	A	124	3.00	2.94	− 2.0	29.2	29.8	+ 2.1
	B	44	3.26	3.09	− 5.2	26.9	28.3	+ 5.2
	C	44	4.02	3.83	− 4.7	21.8	22.9	+ 5.0
	A, B & C	212	3.18	3.09	− 2.8	27.5	28.3	+ 2.9
Jesmond Road (Eastbound) 28 runs	A	97	1.38	1.40	+ 1.4	22.2	21.9	− 1.4
	B	20	1.38	1.38	0	22.2	22.2	0
	C	16	1.72	2.17	+26.2	17.8	14.1	−20.8
	A, B & C	133	1.41	1.47	+ 4.3	21.7	20.8	− 4.1
Jesmond Road (Westbound) 28 runs	A	68	1.45	1.38	− 4.8	21.1	22.2	+ 5.2
	B	10	1.48	1.37	− 7.4	20.7	22.3	+ 7.7
	C	13	1.93	1.57	−18.7	15.9	19.5	+22.6
	A, B & C	91	1.51	1.40	− 7.3	20.3	21.9	+ 7.9

O. & D. Survey

WREXHAM'S TRAFFIC STUDY

by D. M. Craig

B.Sc., A.M.I.C.E., A.M.I.Mun.E., A.M.Inst.H.E.

Deputy Surveyor, Ashford U.D.C., Former Chief Engineering Assistant, Borough of Wrexham.

Fig. 1. Congestion in Wrexham, June 1961.

The following Paper is a description of a comprehensive Origin and Destination Traffic Survey carried out in Wrexham in the autumn of 1959. The methods adopted for the field work and the analysis of the resulting data may be suitable for some other towns.

ALTHOUGH Municipal Engineers have been practising traffic engineering for many years, only recently has it been fully accepted that it is essential to obtain adequate and accurate traffic data before designing new roads, or carrying out major improvements to existing roads and junctions. As much information as possible must be obtained from field studies, and the data thus obtained must be scientifically analysed and assessed. It is imperative that the solution to traffic problems should be obtained by using the results from the analysis and not be based, as has been the tendency until fairly recently, on preconceived opinions and theories.

Origin and Destination studies and data are of prime importance in the planning, design and operation of traffic routes since they determine:

(*a*) The preferred location of traffic routes.
(*b*) The demand which will occur for any route.
(*c*) The routes which will best expedite the movement of traffic over an existing network.

The object of the survey undertaken in Wrexham was to obtain reliable information to support an Inner Ring Road proposal, and to determine which sections of the Ring Road should have priority. The Ring Road proposals are, in essence, the retention and widening of some of the existing roads and the construction of a number of new roads. From a knowledge of the volume and proportion of through traffic (traffic passing through Wrexham on its way from one place outside to another place outside and having no reason on grounds of business or pleasure to enter the town) and from a knowledge of the volume and routing of stopping traffic (traffic stopping in Wrexham on business or pleasure), it was hoped to confirm the need for the proposed Inner Ring Road in whole or in part. In addition, from the information obtained on average volumes of traffic it was hoped that more definite conclusions might be drawn than have been previously possible as to the widths of proposed new roads and improvements to existing roads.

Method Employed

The Ministry of Transport outlined the main methods of conducting origin and destination surveys in the memorandum to Circular 612 of April 16, 1948. These are:

(1) By direct interview of drivers halted at census posts.
(2) By observation of registration numbers of vehicles passing from one census post to another.
(3) By the use of postcard questionnaires handed to drivers for completion and return by post.
(4) By tags on vehicles travelling between census posts.

Only the direct interview method would supply all the information necessary but, unfortunately, it needs the most elaborate organization, particularly for the field work. The results of the survey were required in terms of average 16-hour week-day traffic flows, but the organization and running of such a survey for a complete week simultaneously at the seven census posts involved would have been costly. After consultations with the Traffic and Safety Division of the Road Research Laboratory it was decided to adopt their 'Variable Fraction Sampling Technique' and

to curtail the hours of the survey to between 8.00 a.m. and 6.00 p.m., and to convert to a 16-hour day by the use of the appropriate multiplication factor. This technique prevents any queueing of vehicles at the census posts and does not involve motorists in long and infuriating delays.

Each census post was manned by an enumerator and an interviewer with a police officer to stop the vehicles. In the case of the census post on the Chester Road, however, it was found necessary to have two interviewers, because the road was too narrow to allow other vehicles to pass in both directions when one vehicle was stopped for interviewing. The two interviewers were found to be capable of dealing with practically 80 per cent of the flow in Chester Road during peak flows.

The enumerator counted and recorded *all* incoming vehicles in five classes ranging from mopeds to heavy commercial vehicles. The interviewers questioned *some* of the drivers only, adopting the technique described below.

Police Co-operation

Immediately the survey shift period started the police officer directed the driver of the first vehicle to cross a special reference line, painted across the incoming traffic lanes, to move to the interviewer for the questions to be asked. As soon as the interviewer had received the answers to his questions, he signalled to the police officer, who then carefully picked out the next vehicle to cross the reference line without consideration for type or speed. The driver of this vehicle was asked to halt at the census post and this process continued until the end of the period, when the enumerator also stopped counting. This procedure was carried out implicitly so that an unbiased sample was obtained. The proportion of the vehicles interviewed is immaterial providing there is a count of the total number of vehicles passing; the whole point of this method being that, as a truly unbiased sample is obtained, it can be assumed that if 30 per cent of the vehicles interviewed are going from Point X to Point Y then 30 per cent of the total number of vehicles passing Point X are also going to Point Y.

Local buses on scheduled runs were counted but not interviewed and arrangements were made with the bus company to obtain a list giving destination and routes of all buses coming into the town.

It was considered that the traffic passing each census post would fall into one of the following categories:

(*a*) Incoming vehicles calling in some part of Wrexham.
(*b*) Incoming vehicles passing through Wrexham to some other place.
(*c*) Outgoing vehicles which were simply passing through Wrexham.
(*d*) Outgoing vehicles coming from some part of Wrexham.

It was clear that if incoming vehicles only were interviewed at the census posts, precise information could be obtained about the journeys of vehicles in classes (a), (b) and (c), but not those of class (d). A high proportion of the vehicles in class (d), however, are those involved in journeys between home and offices, shops, etc. and it was thought reasonable to link them with the vehicles in class (a). It was decided, therefore, to assume that all vehicles interviewed at a census post and falling in class (a)—calling traffic—would leave the calling zone in Wrexham during the period of the survey by the same roads as they had entered. This assumption had the effect of reducing the staff required by half as it meant that outgoing traffic could be virtually ignored during the field work.

Standard questions

The following standard questions were put to each driver interviewed:

(1) Where have you come from?
(2) Where are you going?
(3) If Wrexham, which part (give name of street or firm)?

The replies to these questions were recorded by hours on the interview form and the vehicles classified as:

(1) Solo Motor Cycles, Scooters, Mopeds.
(2) Cars, Taxis, Motor Cycle Combinations.
(3) Buses and Coaches.
(4) Light Commercial Vehicles.
(5) Heavy Commercial Vehicles.

Census Posts

Detailed consideration was given to the location of the census posts and it was finally decided to have posts on the main and subsidiary radial routes leading into the town. The number of census posts established was seven and the detailed location of these posts is shown in Fig. 2. on facing page. The positions of the census posts were selected so that they were outside the existing intermediate ring road, thus ensuring that all vehicles which intended going round the existing intermediate ring roads were accounted for before turning off the radial roads. Each portion was inspected in company with the Police Traffic Inspector before the survey commenced and some minor variations were agreed.

Duration and Date of Survey

The survey extended over three consecutive days of one week, namely Thursday, Friday and Saturday, September 17, 18 and 19, 1959, from 8.00 a.m. to 1.00 p.m., and over three consecutive days of the following week, namely Thursday, Friday and Saturday, September 24, 25 and 26, 1959, from 1.00 p.m. to 6.00 p.m. In the case of Census Post F, however, it was decided after consultation with the police to postpone the census on Saturday, September 26, until Saturday, October 3, because the post was outside the local football ground and a league Division III football game was due on September 26.

The days of the week for the survey were chosen after careful consideration and reference to the Ministry of Transport. Monday and Thursday are market days: Tuesday, Wednesday and Friday, are similar to each other and Saturday of course stands by itself. Thursday, Friday and Saturday were, therefore, chosen as being most likely to give the best overall picture of the traffic entering the town in differing circumstances. To obtain an average day it was decided to take one-sixth of the following total:

Three times the Friday traffic + twice the Thursday traffic + the Saturday traffic.

The weather conditions during the survey were ideal with only a negligible amount of rain.

Traffic Analysis on Existing Roads

For analysis purposes Wrexham was divided into 26 numbered internal zones, i.e. inside the existing intermediate ring road and a further seven external zones outside the existing intermediate ring road (Fig. 2). To assist in the initial stages of the analysis two of the 15 enumerators and interviewers engaged on the field survey were retained for a further period of six days. Their task was to write against each destination, on the interview forms, the appropriate zone code numbers.

The sorting by hand of all data from over 26,000 interviews would have been far too laborious a task and it was decided to make use of mechanical aids. The use of punched cards appeared to be most suitable because the Denbighshire County Treasurer's Department had Powers-Samas Equipment and were prepared to assist. The interview sheets were sent to the County Treasurer's Department for tabulation.

Tabulation

A card was punched with the following information for each interview:

(1) Census Post No.
(2) Date.
(3) Hourly Period.
(4) Vehicle Type.
(5) Zone of Destination.

The Zone of Origin was not necessary on the cards because each census post represented traffic originating from one specific external zone.

A summary sheet was then prepared on which the totals were entered of each vehicle type interviewed at particular census posts, dates and hourly periods. From the enumerators' sheets the totals of each vehicle type counted in the same periods were entered above these figures on the summary sheets.

To be consistent with the Ministry of Transport practice it was necessary to produce results on a 16-hour day basis. Calculations based upon several past 16-hour traffic censuses on the radial roads produced the following multiplying factors:

Census Post	
A. Chester Road	1.36
B. Holt Road	1.45
C. Kings Mill Road	1.30
D. Ruabon Road	1.33
E. Ruthin Road	1.30
F. Mold Road	1.33
G. New Road	1.30

The above conversion factors were introduced, therefore, to raise the results from 10-hour to 16-hour standards.

Factors of two-sixths for the Thursday results, three-sixths for the Friday results and one-sixth for the Saturday results were also included to convert the results obtained for Thursday, Friday and Saturday into equivalent average daily figures. Each card was then punched with the appropriate combined weighting for each vehicle class and hourly period and the card then represented a value which was more or less than the single unit it had been at the beginning.

The next stage was to obtain for each class of vehicle total journeys between each origin and destination, and these for convenience were listed in tabular form. It was then possible to produce a combined table for all vehicle classes in terms of Ministry of Transport 'passenger car units' which are defined in Circular 727 as follows:

Motor cycles, private cars and light goods vehicles—1 P.C.U.
Heavy goods vehicles (over 30 cwt. unladen) buses and coaches—3 P.C.U.'s.

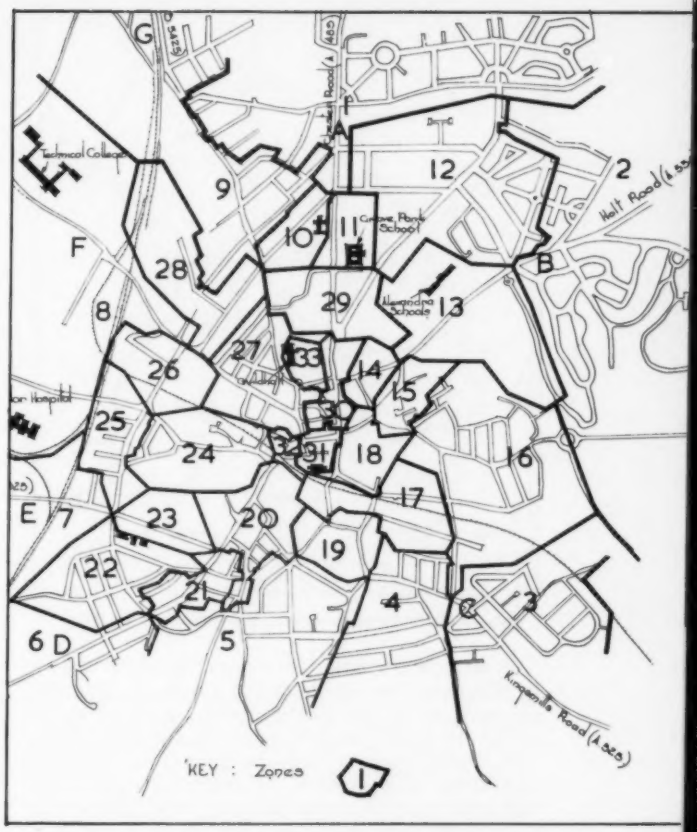


Fig. 2. Internal and external numbered zones.

Assignments

When offered a choice of routes a driver is influenced by various factors. These factors may include journey distances or times, safety, convenience, habit, and local features of interest, etc. Very little research on this subject appears to have been carried out in this country but investigations in the United States seem to indicate that the principal criterion is the time taken or saved, many motorists preferring to take a longer route provided they can save time.

The making of assignments has, until quite recently, involved questions of opinion and a completely objective procedure has not been possible. The Road Research Laboratory has recently evolved a method for determining the route requiring the least journey time between points on a road network. The method also shows how the traffic is distributed between the points. The technique provides basic information on the qualities of a road network without requiring the exercise of any judgment apart from that necessary to define the original network. The procedure is quite mechanical. At each stage of the method the next step is automatic and there is no uncertainty as to when the procedure is complete.

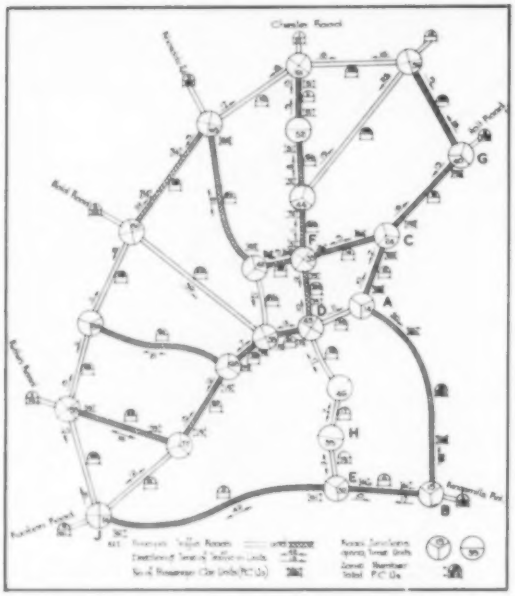


Fig. 3. Diagrammatical layout of principal traffic roads.

Briefly, the procedure for the analysis of the results at Wrexham was as described below. A list was prepared giving the existing principal traffic roads within the area of the present intermediate ring road. This primary stage in the technique was the only part depending upon opinion. In practice no difficulty was experienced in choosing the principal traffic roads and where there were some doubts as to the importance of any particular road it was specifically added to the list for consideration in the subsequent stages of the analysis. Having chosen the principal traffic roads several journey time surveys in both directions were carried out on all the roads listed and the average time taken to travel between junctions was calculated.

A diagrammatic layout of the listed roads and their junctions was then prepared (Fig. 3) and arrows were placed on each of the roads indicating the direction(s) of flow of the traffic. The average time to travel between junctions was placed alongside each arrow but to ease the subsequent calculations the average time was expressed in units, each unit representing three seconds. Every road was given the same number as the zone within which it was contained and for analysis purposes it was assumed that all vehicles originating or terminating in any zone did so at the mid point of the similarly numbered road. The next step was to work out the shortest route, on a time basis, from each origin to every destination. The method of finding the quickest route is, as already stated, quite simple and can be best described by means of an example:

Consider all vehicles originating in Zone 16 (Fig. 2).

(i) Any vehicle originating in Zone 16 can go to Junction A or B and will take 14 units of time to go to Junction A and 15 units to go to Junction B. Insert the times in the respective sectors of Junctions A and B.

(ii) Consider the junction which has the lowest units of time marked on it, in this case Junction A. Connect A back to the mid-point of Zone 16 by means of a hatched line. From A a vehicle can only go to Junction C (it cannot go to Junction D because this would mean going down a one-way street in the wrong direction) and to get to C it will take a further 10 units of time making a total time of 24 units from Zone 16. Insert this total time of 24 units in the appropriate sector of Junction C.

(iii) Consider now the junction which has the lowest units of time marked on one of the sectors and which has not been connected back to Zone 16 by means of a hatched line. In this instance it is Junction B so connect it back to the mid-point of Zone 16 by a hatched line. From B it is possible for a vehicle to go outside the road network altogether or to Junction E which would take 17 units of time making a total time of 32 units from Zone 16. Insert this total time of 32 units in the appropriate sector of Junction E.

(iv) Consider once more the junction which has the lowest units of time marked in one of the sectors and which has not been connected back through to Zone 16 by means of a hatched line. In this instance it is Junction C so connect it back to A by a hatched line. From C it is possible for a vehicle to go to Junctions F or G which would take a further 9 or 16 units of time respectively making total times of 33 or 40 units from Zone 16. Insert these total times of 33 and 40 units in the appropriate sector of Junctions F and G respectively.

(v) Consider once more the junction which has the lowest units of time marked in one of its sectors and which has not been connected back through to Zone 16 by means of a hatched line. In this instance it is Junction E so connect it back to B by a hatched line. From E it is possible for a vehicle to go to Junctions H or J which would take a further 7 or 42 units of time respectively making total times of 39 or 74 units from Zone 16. Insert these total times of 39 and 74 units in the appropriate sector of Junctions H and J respectively.

(vi) The whole process is repeated again and again until every junction and zone is connected back through to Zone 16 by means of a continuous hatched line; when this has been completed it is possible to see quite clearly by means of the unbroken hatched lines the quickest route from Zone 16 to any other point on the road network.

Sheets were produced for each origin and when these had been completed the next stage in the analysis was carried out. This stage consisted of allocating the traffic to various routes and again the method is best described by means of an example:

Consider once more Zone 16 (Fig. 1).

(i) It is known that 514 P.C.U.'s originate from Zone 16 and the first step is to enter in the small circles containing the zone numbers the total P.C.U.'s which go to each individual zone from the origin.

(ii) For the purposes of the allocation it is simpler to reverse the origin and destinations and to consider that all the P.C.U.'s originate in the various zones which are in fact their destinations and go to the one destination which is in fact their origin.

(iii) Starting at the outer zones of the network it can be seen that 51 P.C.U.'s come from Zone 1 through Zones 11, 29 and 30 (a) to Junction F where they are joined by P.C.U.'s from other zones; 34 P.C.U.'s come from Zone 8 through Zone 28 to the junction at Zone 9 where they are joined by 32 P.C.U.'s from Zone 9 giving a total of 66 P.C.U.'s which continue to Junction F by way of Zones 27 (c) and 33; similarly 19 P.C.U.'s come from Zone 7 through Zones 23, 20, 32, 31 and 30 (b) to Junction F. The three streams of 51, 66 and 19 P.C.U.'s combine at F making a total of 136 P.C.U.'s which continue through Zone 14 to Junction C where they are joined by a further 195 P.C.U.'s from Zone 2 making a final total of 331 P.C.U.'s which continue through Zone 15 and Junction A to the mid-point of Zone 16. Similarly 61 P.C.U.'s come from Zone 6 through Zones 5 and 4 to Junction B where they are joined by 122 P.C.U.'s from Zone 3 making a final total of 183 P.C.U.'s which continue to the mid-point of Zone 16. The same process was repeated with each origin so that eventually there was one sheet for every origin showing the quickest routes and the distribution of traffic thereon.

The final stage in the analysis of the existing road network was to produce a master sheet showing the total volume of traffic on all the listed roads within the network. To produce this sheet combined totals were made of all the P.C.U.'s carried by each separate road, as shown by the individual sheets and in addition at this point the number of buses, if any, carried by each road was also added in the form of P.C.U.'s. The service buses of course do not necessarily take the shortest or quickest route and therefore they were not included in the initial stage of the analysis but allocated separately.

The combined totals were then inserted on the appropriate road on the master sheet. Although the master sheet indicated the volume of traffic carried by each road, the information contained in it was not immediately obvious to the eye. It was decided, therefore, to produce another master sheet giving a pictorial representation, the width of road being made directly proportional to the volume of traffic carried (Fig. 4).

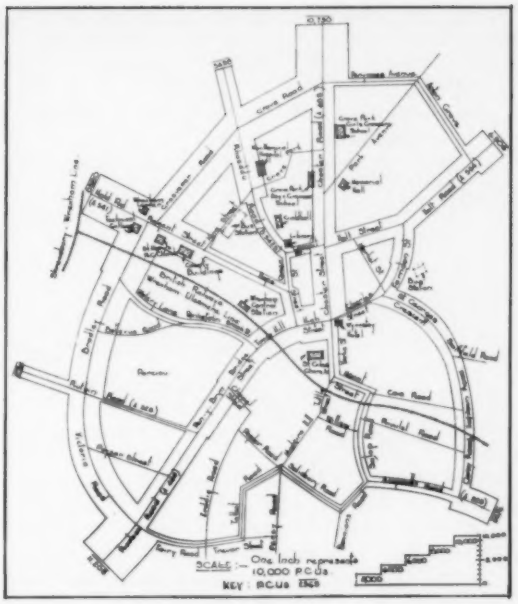


Fig. 4. Distribution and traffic on principal roads.

Traffic Analysis on Alternative Ring Roads

Proposals for the possible routes of the Inner Ring Road had been the subject of discussions between the County Council, the Borough Council and their respective Chief Officers for some time. Bearing in mind the existing layout of roads and buildings within the Borough and the land which is already owned by the Council, the probable route decided upon for the southern section of the proposed Inner Ring Road was thought to have no reasonable alternative. A decision on the probable route of the northern section was not so easily arrived at, however, but eventually two possible routes emerged. These routes are known locally as the 'King Street' line and the 'Hospital' line. For ease of description the lines will be designated as follows:

Route A—King Street line along with the common southern section of the Inner Ring Road.

Route B—Hospital line along with the common southern section of the Inner Ring Road.

Having decided upon two possible routes it was necessary to carry out further full analyses to produce master sheets incorporating Route A and master sheets incorporating Route B. These master sheets were prepared by the same method as that described earlier, with the assumption that the whole of the route of the Inner Ring Road was already in existence.

In the case of the sections of the Inner Ring Road which are not yet constructed it was necessary to calculate the probable journey times between junctions. The journey time was worked out by measuring the length of each proposed new section of road and assuming that the average speed of vehicles using the road would be 40 ft./sec. (i.e. approx. 27 m.p.h.). These times were marked on the appropriate assignment sheets and for ease of reference each proposed new section of Inner Ring Road was given its own zone number, although, of course, no traffic could be considered as having these zones as origins or destinations.

By-Passable Traffic

In view of the fact that it is intended to construct a by-pass on the Western side of the town in connection with the Manchester-Swansea Trunk Road it was considered desirable to find out the effect this would have on traffic volumes in the town. From the data already obtained it was possible to extract information on by-passable traffic and therefore it was comparatively simple to produce six more master sheets (numbered and pictorial) showing respectively the existing road system with the by-pass, the existing road system with the King Street line and the by-pass and the existing road system with the Hospital line and the by-pass. The analysis of the survey revealed that some 39.2 per cent of the total number of P.C.U.'s entering the town by way of Chester Road, Ruabon Road, Ruthin Road, Mold Road or New Road (i.e. passing Census Posts A, D, E, F and G) is by-passable.

Conclusions and Recommendations

Because of the existing road pattern of the town which is a typical example of a radial plan, a ring road system to deal with traffic suggests itself and this is borne out by the diagrams and tables. It is an obvious conclusion to draw from the comparatively high volume of traffic which passes through the centre of the town and which is potentially by-passable, that some form of road plan which will keep such traffic out of the central area and help to reduce congestion is not only desirable but essential.

The various diagrams prepared give an indication of the volume and distribution of traffic on the existing road system. It can be seen that, despite the relatively successful attempt at present operating to by-pass some of the through traffic by way of Grove Road, Grosvenor Road, Bradley Road and Victoria Road, there is still a considerable volume of traffic concentrated on the central area. In particular, Chester Street, High Street, Town Hill and Hope Street are very congested even with the Limited Waiting, No Waiting and One-Way Street regulations

which have been introduced. It would appear, therefore, that there is a clear case for some form of inner ring road which would allow traffic to go round the central area rather than through it.

On comparing all the possibilities it could be seen:

(1) *Without the by-pass*
- (*a*) Route 'B' attracts a higher volume of traffic than Route 'A'.
- (*b*) Route 'B' gives greater relief to the central area.
- (*c*) Route 'A' concentrates very high volumes of traffic at the junctions on Grosvenor Road.

(2) *With the by-pass*
- (*a*) Route 'A' attracts a slightly higher volume of traffic on the northern section than Route 'B' but slightly less on the southern section.
- (*b*) Both routes 'A' and 'B' give almost exactly the same relief to the central area.
- (*c*) Route 'A' still concentrates a fairly high volume of traffic at the junctions in Grosvenor Road.

Having regard to the fact that there is no immediate prospect of the by-pass being constructed it would appear that Route 'B', the Hospital line, will prove the more satisfactory and it will give more immediate relief to the central area which of course is one of the primary objects of the inner ring road.

At the time this paper was being written (late 1960) no recent final recommendations were available regarding allowances for future traffic volumes. It was believed, however, that the following recommendations on future designs standards for roads were likely to be made:

(1) Estimates of future traffic volumes should be based on 150 per cent in excess of the average daily flow in 1959 i.e. giving a total of 250 per cent of the figures obtained during the survey.

(2) Limiting capacities of carriageways should be assumed to be as follows:—Two-lane carriageways—up to 6,000 passenger car units per 16-hour day.
Three-lane carriageways—6,000 to 11,000 passenger car units per 16-hour day.
Dual two-lane carriageways—11,000 to 25,000 passenger car units per 16-hour day.

It was decided, therefore, to take these future design considerations into account when making recommendations as to the widths of new roads and the widening of existing roads. An examination of the appropriate master sheet showed that the necessary widths for the inner ring road and the by-pass ranged from a dual two-lane highway for the latter to a simple two-lane highway for a short section of the former.

ACKNOWLEDGMENTS

I should like to thank Mr. J. M. Davies, M.I.Mun.E., L.R.I.B.A., Borough Surveyor of Wrexham for allowing me to submit this Paper and for his encouragement and advice. My thanks are also due to the Director of Road Research and the members of his staff at Langley and members of the Wrexham Borough Council's staff who gave such willing assistance during the coding, analysis and presentation of the results.

Moving-Observer Method *concluded from page* 162.

of traffic flow and the average journey speed between 10 a.m. and 11 a.m. on a specific day. Preliminary observations have shown that the total two-way flow is of the order of 600 vehs. per hr. or 10 vehs. per min. and the journey speeds around 20 miles per hour. Assuming nine test runs in each direction of flow, we have:

$$\text{Sampling Time} = \text{Number of test runs} \times \text{Length of test route} \times \text{Rate of motion}$$
$$= (2 \times 9) \times (0.50) \times (3.0)$$
$$= 27 \text{ mins.}$$

The Standard Error (S_a) of the estimated mean flow would be:

$$S_a = 1.21 \, (Q/T)^{\frac{1}{2}} \times (1 - T/D)^{\frac{1}{2}}$$
$$= 1.21 \, (10/27)^{\frac{1}{2}} \times (1 - 27/60)^{\frac{1}{2}}$$
$$= 0.55 \text{ veh. per min.} = 33 \text{ vehs. per hr.}$$

The two-way flow estimated by the moving-observer method would therefore be within $\pm$ 2 Standard Errors i.e., $\pm$ 66 vehs. per hr. of the true flow on 95 occasions out of 100. In terms of the assumed mean flow of 600 vehs. per hr., this limit of deviation of the estimate would be 66/600 or 11.0 per cent, which would be an acceptable limit of statistical accuracy for this type of study.

Keeping the length of test route constant at 0.50 miles a more precise estimate of the two-way flow would be obtained by increasing the number of test runs beyond 18, thereby increasing the sampling time. Alternatively, the number of runs could remain constant at 18 and a longer length of test route could be used, provided there were no major intersections which prohibited such a procedure.

If it were required to estimate the average flow between 10 a.m. and 11 a.m. over five week-days, the upper limit of sampling time would be 300 minutes. For such a study the case could therefore arise where the sampling time required for an acceptable estimate of average traffic flow per hour would be in excess of 60 minutes.

Note on Standard Error

The Standard Error of the arithmetical Mean of a sample batch of results is a statistical measure of the reliability of that Mean as an estimate of the true Mean of the population from which the sample has been taken. Irrespective of the type of distribution of the population, the distribution of the sample Means approaches the normal or Gaussian form as the sample size increases. When the distribution is normal, the probability of obtaining the Mean of the sample which deviates from the Mean of the population by more than twice the Standard Error is one chance in 20.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the financial support received from the trustees of the Rees Jeffreys Road Fund. The Work described in this paper is part of a research programme concerned with the basic characteristics of traffic flows in urban areas which is being carried out in the postgraduate school of highway and traffic engineering in King's College, Newcastle upon Tyne, in the University of Durham.

REFERENCES

[1] WARDROP, J. G. and CHARLESWORTH, G. (1954). A Method of estimating speed and flow of traffic from a moving vehicle. *Proc. Inst. C.E. Part II, Vol.* 3.

[2] WILKIE, L. G. and GRAN, R. F. (1956). *Moving vehicle method of estimating traffic volumes and speeds.* Cooke County Highway Department, Illinois.

[3] NATIONAL COMMITTEE ON URBAN TRANSPORTATION (1958). *Procedure Manual: Determining Travel Time.* Public Administration Service, Chicago, Illinois.

REFLECTORS on ROADS with RAISED KERBS

by

A. W. Christie, M.A., B.Sc.

Road Research Laboratory

Fig. 1. Concrete kerbs with reflecting facets seen in full headlights where the surface was damp. The kerbs were of the type shown in Fig. 2.

It is helpful to drivers on unlighted roads to have reflectors near the edge of the carriageway which will appear bright in their headlights. However, the effectiveness of such reflectors may be greatly reduced by mud splashed up by passing vehicles. In this article the problem is discussed so far as it affects roads with raised kerbs. The problem of flush edge markings for use on roads with hard shoulders is still under study.

THERE is usually not much difficulty in good daylight or at night under good street lighting in seeing the edge of a road lined with raised kerbs with a vertical or a splayed riser. Nor is there much difficulty when using headlights on unlit roads on clear dry nights. On foggy and wet nights, however, it may be difficult to see the position of the kerb in the light of headlights. The effect of fog on visibility requires no explanation, but the effect of wetness may not be so obvious. The light from headlights is incident so obliquely on the faces of the kerb that when they are wet the light is reflected preferentially in directions close to the direction of mirror reflection which is, of course, away from the driver. The kerb, therefore, appears rather dark, and the same is true of the road surface, unless it has a coarse texture to break the water film. It is worth adding that most concrete kerbs have a smooth finish and that even on dry nights there is a tendency for such kerbs to appear darker than kerbs of the same colour with a coarse finish.

There are two obvious methods for increasing the amount of light returned by the kerbs—making them white and giving them a rough finish. The first method has little effect unless combined with the second (except in the case of the kerbs confronting drivers at sharp bends, T-junctions and roundabouts which present faces nearly perpendicular to the headlight beams). Even then the gain is likely to be marginal, as has been shown by experiments with a kerb with an exposed aggregate of white calcined flint: the white colour was soon lost when the road became muddy during the winter and the surface texture was barely coarse enough to provide good visibility on wet nights.

A more satisfactory wet-night performance has been achieved with kerbs moulded so as to have facets roughly perpendicular to the headlight beam. One such design is shown in Fig. 2. On a dry night the brightness of these concrete facets is only a little higher than that of the other parts of the kerb. However, when rain falls the brightness of the facets alters little whilst the brightness of the other parts of the kerb (and usually also the brightness of the road surface) falls because they begin to reflect preferentially. Thus when wet the facets may be markedly brighter than their surroundings (3 to 10 times). The appearance of an installation of such kerbs when the road was only slightly damp is shown in Fig. 1.

Since the reflection from these concrete facets is mainly diffuse, their performance is not greatly affected by small deposits of mud. During the winter months, however, they may become heavily plastered

Fig. 2. Concrete kerbs with facets perpendicular to the headlight beam.

with mud and they then cease to function properly. Usually by spring they clean up sufficiently to be effective once more on wet nights. It appears that such kerbs would have to be brushed regularly to maintain their effectiveness throughout the winter.

A similar kerb with facets of white vitreous enamel has also been tried but after the facets became splashed with mud they did not regain their original whiteness. Although rain removed most of the mud a brownish scum always remained. Indeed, so tenacious was this scum that it could not even be removed by a jet of water from a hose. An analysis of a sample of mud from the kerbs showed that it contained 3 per cent (by dry weight) of oily material (soluble in benzene).

Since the above sample was from a kerb bordering a bituminous surfacing it seemed possible that some at least of the oily material might come from the bitumen. A sample from a concrete road was analysed to test this and the proportion of benzene-soluble material was found to be 2 per cent, and it seems fairly certain that the bulk of the oily material comes from the vehicles using the road.

This type of kerb has one disadvantage. On wet nights, in situations as shown in Fig. 1, opposing headlights would produce a bright reflection on smooth faced kerbs on the outside of the bend. With the serrated formation necessary to provide facets perpendicular to the driver's own headlight beams this effect is partly lost. However, with the serrated kerb tested, sufficient reflection from opposing headlights is still obtained from the parts of the rising face of the kerb above and below the facets. There can be little doubt that the advantage, therefore, lies with the kerb with facets. Whilst this type of reflecting kerb is quite successful on wet nights, and is not severely affected by small deposits of mud, it does not give a sufficiently intense signal to be of much assistance in thick fog. Better performance in fog can be obtained using reflex reflectors.

Kerbs Incorporating Reflex Reflectors

Reflex reflectors are devices which return the light from a vehicle headlight in a narrow cone towards the headlight (the cone having sufficient spread to include the eyes of the driver), and which do this for a wide range of positions of the vehicle. Examples of such reflectors are the rear reflectors on road vehicles, the reflectors set in the lettering of some road signs, the reflective sheeting used on certain other road signs, and the reflective materials used for road markings. For the first two purposes glass or plastic reflectors of the biconvex or corner-cube type are generally used. The reflective sheet material consists essentially of an array of glass spheres (ballotini) backed by a shiny metal foil and coated with a clear varnish so as to have a smooth finish. For reflective road markings, ballotini embedded in paint or thermoplastic are sometimes used.

Where reflex reflectors are used to mark the edge of the road the convention is to have red reflectors showing on the nearside and white reflectors showing on the offside. One type of kerb with reflectors let into slots in the riser is shown in Fig. 3. The reflector may be of any of the types described above. Provided that the design of the kerb is such that the reflectors can be seen from an adequate distance (200 ft. or more seems to be desirable), such reflectors are very effective when clean. Those showing to the nearside are, however, extremely vulnerable to mud splash. When the kerbs shown in Fig. 3 were tested on a trunk road, the reflective power of the reflectors was reduced to less than 1 per cent of the original value in four weeks (during the winter). If the reflectors are in recesses (as in Fig. 3) heavy deposits of mud tend to be retained. If, on the other hand, the reflectors are exposed to falling rain, most of the mud will be washed away after the winter but an oily film, which by itself is sufficient to reduce the reflective power of the reflectors to about 10 per cent of its initial value, is left. Reflectors showing to the offside are much less affected by mud and may continue to serve a useful purpose throughout the winter.

Manual cleaning of kerb reflectors is not a satisfactory solution to the problem since the effect of such cleaning can be undone in a few hours. Another possibility is to have a wiping arm actuated by

Fig. 3. Concrete kerbs with reflex reflectors in slots.

Fig. 4. Self-wiping reflecting road studs set in the channel close to the kerb.

passing vehicles depressing a pad in the road. Such a reflector has been tested on a trunk road. It was found to work very well for about four months but after that various mechanical faults developed.

An obvious device to try is the familiar self-wiping reflecting road stud. This has biconvex glass reflectors whose front faces are wiped each time the pad in which they are mounted is depressed by the wheel of a vehicle. These were found to be unsatisfactory when tried in the channel close to the kerb (Fig. 4), as in this position they soon became completely choked with dirt. No doubt they would prove satisfactory if moved further into the carriageway but would then be a danger to cyclists. If installed on the riser of the kerb they are damaged by vehicle tyres rubbing the kerb. If installed on the top of the kerb they are not actuated by vehicles and become inoperative when the road is muddy, unless actuated by pedestrians or the road cleaner.

Reflex Reflectors on Posts

Reflex reflectors for indicating the edge of the carriageway are sometimes mounted on posts. The effect of mud lessens, both with the distance from the edge of the carriageway and with the height above the carriageway as illustrated in Fig. 5, which shows the reflective power of reflex reflectors after 26 days exposure, expressed as a percentage of the

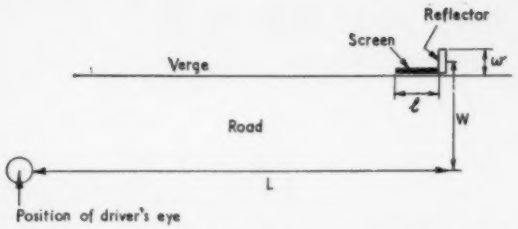


Fig. 6. The arrangement used in an experiment to test the possibility of screening reflectors on posts from mud splash.

original value. This experiment was carried out on a trunk road during the month of March. Six of the 26 days were wet and the total rainfall was 0.5 in. The measurements were made using the Road Research Laboratory reflex reflector photometer[1] with 0° angle of incidence and 0.3° angle of observation.[2] These results show that the required frequency of cleaning is reduced if the reflector is moved further away from the carriageway and raised higher above it. Unfortunately there is no practical distance or height at which no cleaning is required.

There are in any case disadvantages in mounting the reflectors high and siting them away from the carriageway edge. Both measures reduce the illumination reaching the reflectors from headlights and both make it more difficult for drivers to estimate the position of the carriageway edge even when the reflectors can be clearly seen. An experiment has therefore been carried out to find whether reflex reflectors on posts close to the edge of the carriageway can be screened from mud splash.

A plan view of the arrangement tested is shown in Fig. 6. Let w be the width of the reflector and l the length of the screen. The reflector may not be seen by an approaching driver after he comes within a certain distance of it. If the driver's path lies a distance W to the right of the reflector then the whole of the reflector will be completely hidden from view by the screen at distances less than $L = W(l/w)$. On the other hand, if the mud splashed up by vehicles travelling in straight lines, the reflector would be shielded from the mud splashed up by vehicles within a distance L of it. In the experiment two lengths of screen were used, $l/w = 3.5$ and $l/w = 4.5$, to protect reflectors at heights between 2 and 3 ft. above the road surface. The cut-off distances for

Concluded on page 175

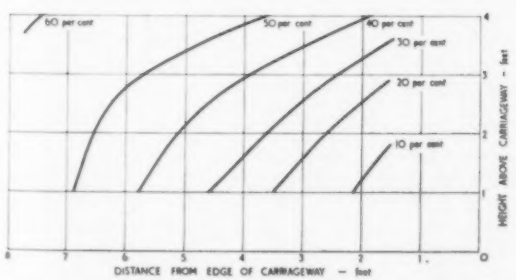


Fig. 5. The effect of mud splash on reflective power of reflex reflectors on posts. Reflective power after exposure for 26 days in March, expressed as a percentage of the original reflective power.

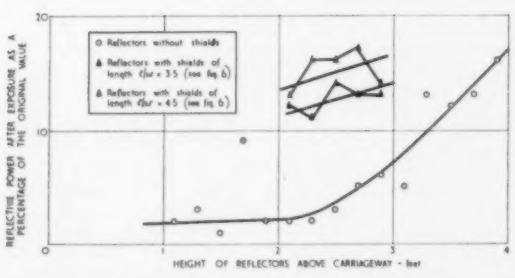

○ Reflectors without shields
▲ Reflectors with shields of length l/w = 3·5 (see fig. 6)
▲ Reflectors with shields of length l/w = 4·5 (see fig. 6)
REFLECTIVE POWER AFTER EXPOSURE AS A PERCENTAGE OF THE ORIGINAL VALUE
HEIGHT OF REFLECTORS ABOVE CARRIAGEWAY – feet

Fig. 7. Effect of mud on the reflective power of reflex reflectors on posts 18 in. from edge of carriageway, with and without shields. The reflectors were exposed for one month during which 1.3 in. of rain fell.

TRAFFIC CONTROL DEVICES MANUAL

II Signals and Islands

by Burton W. Marsh and William L. Carson
American Automobile Association

Fig. 1. State Highway with characteristic layout and traffic control devices, including lane and verge markings and median strip.

AS NOTED in Part I of this report, presented in the June issue of *Traffic Engineering & Control*, publication this year of a revised Manual on Uniform Traffic Control Devices will be an important step toward achieving greater uniformity in the usage of traffic control devices in the United States. It should be repeated that each state among our 50 has independent authority as to most of its traffic control devices. Moreover, in most states, each county and city has a large degree of autonomy as to traffic control devices. The Manual will be a valuable guide and instrument for U.S. states and communities in their endeavours to improve the safety, efficiency and convenience of vehicle and pedestrian movements.

The new Manual's basic provisions as to signs and markings were discussed in Part I of this report. This article deals with two additional and equally-important sections—Signals and Islands. While the different types of traffic control devices are treated separately in these reports, their application and usage should be co-ordinated closely. This is particularly true in the instance of urban intersection control, where the installation of one type of device frequently requires the installation, modification or removal of another.

Signals

Highway traffic signals include all power-operated traffic control devices (except flashers, signs and markings) by which traffic is warned or is directed to take some specification.

The 1961 U.S. Manual contains comprehensive material on the design, location, legal meaning, operation, and maintenance of all types of traffic signals. As in the instance of chapters on other traffic control devices, the new Manual's section on signals contains important changes in the provisions of earlier U.S. Manuals and includes material on matters not previously covered. Extensive experience and research, since publication of the previous Manual in 1948, have made it possible to eliminate certain options in signal design and usage and to set forth more specific standards

The Manual defines highway traffic signals as:

> All power-operated traffic control devices except flashers, signs and markings, by which traffic is warned or is directed to take some specific action.

The Manual warrants, on which determinations as to the installation of traffic signals should be based, are set forth for rural and urban conditions.

The Manual places traffic signals in four classifications, according to their operating functions:

(1) Traffic control signals (pre-timed and traffic-actuated).
(2) Pedestrian signals.
(3) Special traffic signals.
(4) Train-approach signals and gates.

Traffic Control Signals

Many of the provisions set forth in the Manual apply equally to pre-timed and traffic-actuated signals. Standards and requirements applicable to both types of traffic control signals, often called stop-and-go signals, include the following:

(1) Each vehicular signal face shall have at least three lenses (red, yellow and green), except where a green arrow lens is used alone to permit continuous movement. The yellow indication is needed to warn approaching traffic of a pending signal change, to provide a clearance interval for traffic within an intersection or so close that it cannot safely stop before entering and, by flashing, to serve as a caution signal when the traffic signal is not being operated as a stop-and-go device. A yellow clearance interval normally of three to five seconds should be used following each green interval and, where applicable, after each green arrow interval. A yellow interval is never to be used in the red-to-green signal change.

(2) Signal lenses preferably should be in a vertical line, with the red at top, the yellow immediately below and the green at the bottom. For horizontal mountings, the red lens is to be at the extreme left, the yellow next, and the green at the right.

(3) Green arrow indications are to be used at intersections where signals for individual turning movements are provided and, generally, in close proximity to the movement they control. When two or more such lenses are in the same vertical line, the straight-through arrow (pointing up) shall be below the circular green, if any, the left-turn arrow next and the right-turn arrow at the bottom. Green arrows should point in the approximate direction that vehicles are to move, with arrow lenses showing no more than one arrow direction each.

(4) Combinations of signal colours are not to be displayed simultaneously except where, under certain conditions, green turn arrows may be shown with yellow or red.

(5) Vehicular signal lenses shall be circular in shape, except that green arrow lenses may be rectangular. Approved sizes for circular lenses are 8 in. and 12 in. (nominal diameter), the latter often being justified at rural and other high-speed intersections, certain isolated intersections, and locations where signals have competition for the driver's eye. In many U.S. communities, a 12 in. red lens is used with 8 in. yellow and green lenses so as to give special emphasis to the most restrictive indication.

(6) No lettering should appear on vehicular signal lenses, since this would reduce their effectiveness.

(7) Signal lenses shall be illuminated independently and should be clearly visible to drivers at a distance of 1,000 ft. under all atmospheric conditions except dense fog. Visors or louvers should be used on signal faces if needed to prevent drivers from seeing indications not intended for them.

(8) A minimum of two vehicular signal faces shall be visible to drivers on each intersection approach. Where all signal faces are mounted on posts or pedestals, there shall be at least two faces on the far side. If there is a single post- or pedestal-mounted signal face, it is to be placed on the far side and supplemented by a face mounted on a mast-arm or span-wire.

(9) Post-mounted signal faces should be 8 to 15 ft. above the sidewalk or the highway. In the instance of suspended signals, the signal housing shall be 15 to 17 ft. above the roadway.

In addition to a complete treatment of the above matters, the Manual deals briefly with related subjects including roadway widening to improve signalization, signal head mountings, efficiency of signal operation, traffic signals near grade crossings, emergency and civil defence operation of traffic signals, and signal maintenance. Discussed at some length are the respective advantages of pre-timed and traffic-actuated controls and their adaptability to different conditions.

Pre-timed Signals

A pre-timed signal is defined as:

> A traffic control signal which directs traffic to stop and permits it to proceed in accordance with a single predetermined time schedule or a series of such schedules.

The Manual indicates that a thorough engineering study of the location involved is needed in order to ascertain the necessity for signal installation and to provide data for the design and operation of warranted signals. Information and data that are generally needed relate to pedestrian and vehicular volumes, 85 percentile speeds of vehicles on intersection approaches, physical characteristics and conditions, and accident experience over a period of at least one year. Also desirable in some cases are data on vehicle delays and on vehicular traffic gaps.

The Manual sets forth specific warrants to be met for the installation and operation of pre-timed signals. The individual warrants involve minimum vehicular volumes, interruptions of continuous traffic, minimum pedestrian volumes, progressive movement, accident experience, and combinations of these warrants (where none of the previous warrants is met but where at least two others are nearly satisfied).

Where the 85 percentile speed of major street traffic exceeds 40 m.p.h., or when the intersection lies within the built-up area of an isolated community of less than 10,000, the minimum fixed-time warrants shall be 70 per cent of the regular requirements in recognition of differences in the nature and operational characteristics of traffic in urban and rural environments. Considerable information is also given on the types of signal timing that can be employed, cycle time division, and conditions effecting efficiency of signal systems.

Traffic-Actuated Signals

The Manual defines a traffic-actuated signal as:

> A type of traffic control signal in which the operation is varied in accordance with the demands of traffic as registered by the actuation of vehicle or pedestrian detectors.

Such signals are of three types;

(*a*) Semi-traffic-actuated: where the signals are actuated by traffic on one or more, but not all, intersection approaches.

Fig. 2. Pedestrian controlled signal which shows 'Walk' in green and 'Don't Walk' in red.

(*b*) Full traffic-actuated: where signals are actuated by traffic on all intersection approaches.

(*c*) Traffic-adjusted: where signals are continuously adjusted on basis of information received by an electronic computing master control from sampling detectors in the area involved.

Since traffic-actuated signals respond quickly to changes in traffic conditions, and normally do not delay traffic unnecessarily, the Manual indicates that it is inadvisable to establish minimum warrants for their installation. Cited, however, are a number of factors that should influence decisions on the installation of traffic-actuated signals. They include: vehicle and pedestrian volumes, accident hazards, relation of volumes on intersecting streets, complexity of intersection layout and traffic movements, and effects of traffic-actuated signals upon an existing signal system. Also enumerated are conditions that may warrant the installation of traffic-actuated signals at locations other than intersections.

Pedestrian Signals

A separate chapter of the Manual covers pedestrian signals, that is signals erected solely to direct pedestrian traffic at signalized locations. Warrants are set forth for the installation of pedestrian signals in conjuction with a normal signal cycle as well as with cycles providing an exclusive or semi-exclusive pedestrian phase.

The Manual specifies that pedestrian signals shall be rectangular and shall present the messages '*Walk*' and '*Don't Walk*.' Two types of design are approved: (1) Gas-filled, formed tubing, or cut-out letter type having letters at least 4½ inches high, in two lines, with the '*Walk*' indication in green and the '*Dont*' *Walk*' indication in red. (2) The incandescent type, with letters at least 3 inches high and the word '*Walk*' in white, the message '*Don't Walk*' in orange, the two messages to be in separate signal sections.

Special Traffic Signals

The U.S. Manual classifies flashing beacons, lane-direction-control signals and traffic signals at drawbridges as 'Special Traffic Signals.' A flashing beacon is defined as:

> A section of a standard traffic signal head or similar-type device having a yellow or red lens in each face, which is illuminated by intermittent flashes.

It is used mainly at locations where traffic signals are not justified but where special hazards exist. Design is to be consistent with the Manual specifications for standard traffic signals.

One of the major revisions in the new Manual concerns lane direction control signals, employed to indicate and control the direction of traffic movement in individual lanes. Such signals are installed over each lane of the roadway. These signals are being increasingly used in the United States as authorities seek to obtain maximum capacity from existing streets and highways through the establishment of reversible lanes: traffic in a particular lane travels in one direction during a certain period and in the opposite direction during other times.

The Manual provides that lane direction control signals shall have one face for each direction of traffic flow and shall be located over the centre of the lane to which they apply. A downward pointing green arrow is to be displayed when a lane is available to traffic, a red 'X' symbol when a lane is not to be used by vehicles approaching this indication. The Manual sets forth requirements regarding the location and operation of lane direction control signals as well as warrants for reversible lane operation.

Islands

Another chapter of the Manual deals with islands—defined areas between traffic lanes for the control of vehicle movements or for pedestrian refuge. Although certain minimum standards as to design are suggested, the Manual is concerned primarily with the traffic-control characteristics of islands rather than their design features. It notes that guidance as to island design can be found in the publications 'A Policy on Geometric Design of Rural Highways,' 1954, and 'A Policy on Arterial Highways in Urban Areas,' 1957, as adopted and published by the American Association of State Highway Officials.

Islands are classified as refuge islands, divisional islands or channelizing islands. The Manual discusses numerous factors and principles applicable to all three types, including:

(1) The shape of the island should conform as closely as possible to natural vehicular paths and generally should be narrow and elongated, or triangular.

(2) Although desirable island sizes will be governed by site conditions, suggested minimum areas are 75 sq. ft. in rural sections, 50 sq. ft. in urban places.

(3) The proper means of designating an island area will depend upon various factors and characteristics at the location involved, but generally should be by: (*a*) kerb outlines with an interior of pavement, turf or other material; (*b*) pavement markings, buttons, or raised bars—usually at places where vehicle speeds are low; or (*c*) guide posts, stanchions or other delineators, where island is unsurfaced.

(4) Drivers approaching an island should be warned of its presence, and given clear indications as to their proper paths, through careful design of the end of the island. There is no standard type of treatment to effect this at the approach end, but experience has shown various types of devices to be satisfactory under appropriate conditions. They include pavement markings, signs, reflecting devices, flashing yellow beacons, pavement colouring, raised bars and buttons, and illumination devices. Standards have been developed for the utilization of these individual devices, which normally are used in combination.

(5) A gradually widening marking or a roughened strip of road surface should be used to lead traffic into proper paths during their approach to an island.

Although the principal function of refuge islands is to provide a safe stopping place for pedestrians, such islands also expedite vehicular traffic by allowing certain vehicles to proceed without being delayed by crossing pedestrians. They are used mainly on wide streets and at large or irregularly-shaped intersections carrying heavy vehicular traffic. It is desirable that a raised platform with barrier kerbs be used for at least part of a refuge island. Large buffers of concrete or other material at the approach end of refuge islands are not recommended because of their possible contribution to the injury of occupants of a vehicle colliding with the buffer. The Manual indicates that such barriers should be used only where vehicle speeds are relatively high.

Divisional islands are used to divide traffic streams, and usually to separate traffic flowing in opposite directions. They are designated 'medians' (the term 'central reserve' is more common in Britain) when placed over a continuous length of street or highway. These islands are also used to separate traffic flows in the same direction (such as in dividing left-turn movements from through traffic movements), to direct traffic around roadway obstructions and to prevent passing manoeuvres, etc.

At intersections, divisional islands should be at least 20 feet wide to provide adequate protection for crossing or turning vehicles. The minimum desirable width for a median providing a left-turn lane is 16 feet.

Channelizing islands are installed to control and direct drivers safely into proper paths. Their shapes and sizes vary widely, being dependent upon characteristics and conditions at the intersection involved.

Fig. 3. Overhead traffic control signals for improved visibility to driver. Interrogating light—suspended from above—illuminates when signal is controlled from emerging vehicle. A channelizing left-turn lane is on left of centre island.

The number of channelizing islands at a given location should generally be held to a minimum. The principles and factors to be considered in their design and installation are basically the same as those for pedestrian and divisional islands.

Conclusion

Much progress in improved and more uniform usage of traffic control devices in the United States has resulted from the development of a national Manual.

Copies of the new U.S. Manual may be secured from the U.S. Government Printing Office, Washington 25, D.C., at $2.00 per copy.

Concluded from page 171

drivers 10 ft. from the edge of the carriageway were therefore 35 and 45 ft. For comparison, unscreened reflectors at heights ranging from 1 to 4 ft. were also used. All the posts were sited 18 in. from the edge of a trunk road. The reflective powers of the reflectors expressed as percentages of the initial values are shown in Fig. 7. The shields reduced the amount of mud falling on the reflectors but the effect was disappointing: the effect of the longer shield was no more beneficial than raising the reflectors by 18 in. The reason for this seems to be that passing vehicles create a mist of mud particles which may be carried behind the screens by the air turbulence created by the vehicle.

Conclusions

The problem investigated was how to make the edge of the carriageway of ordinary roads without hard shoulders and with raised kerbs more visible at night in headlights. The devices tested were reflecting kerbs, reflecting road studs and reflectors on posts. The main conclusions were as follows:

(i) Concrete kerbs are made more conspicuous (especially in the wet) by the provision of concrete facets set at right angles to headlight beams. Small deposits of mud have little effect, but normally if such kerbs are to remain effective throughout the year, the large deposits that accumulate during the winter months would have to be brushed off. Even when clean, such kerbs are of little assistance in thick fog.

(ii) Any reflective marking, to be effective in thick fog, must incorporate an efficient reflex reflector.

(iii) Reflex reflectors set in the kerb are particularly vulnerable to mud splash and require frequent cleaning in winter. The mud deposited on them contains an oily component which is not washed away by rain.

(iv) Several methods of using the familiar self-wiping reflecting road stud have been considered. If installed in the channel, they become clogged with mud; if moved further into the carriageway they might prove dangerous to cyclists; if installed on the rising faces of the kerb they are damaged by vehicles; if installed on the top faces vehicles do not run over and the wiping mechanism is inoperative, but they could be actuated by the road cleaner.

(v) Reflex reflectors on posts are less affected by mud splash than similar reflectors in the kerb. Raising the reflectors and moving them away from the carriageway reduces the necessary frequency of cleaning but in these positions the reflectors are less strongly illuminated by headlights and give a less clear indication of the position of the kerb. A reasonable compromise seems to be to have the reflectors at about the same height as headlights.

ACKNOWLEDGMENTS

The experiments described above were carried out on a trunk road and a classified road in Middlesex. The kind co-operation of the County Surveyor is gratefully acknowledged.

The article is published by permission of the Director of Road Research.

REFERENCES

[1]Road Research Laboratory. Reflex reflectors. *Department of Scientific and Industrial Research, Road Research Technical Paper* No. 42. London, 1958 (H.M. Stationery Office).

[2]Definitions of these angles are given in the paper quoted above and in B.S.873:1959. The construction of road traffic signs and internally illuminated bollards.

Fig. 1. The First Narrows Crossing Bridge in Vancouver, B.C., Canada, as it nears completion
Photo: John Laing & Sons Ltd.

DEVELOPMENTS

Fig. 2. The approach ramps to the First Narrows Crossing Bridge, showing the toll gate area and the grade separation of the junction of two of the main approach roads

Photo: John Laing & Sons Ltd.

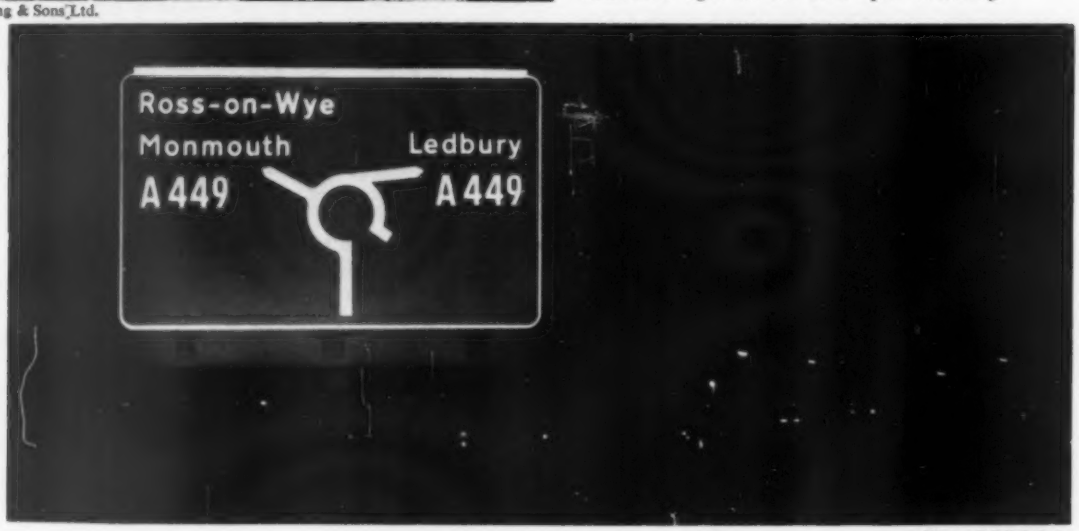


Fig. 3. A night-time view of one of the new illuminated signs on the Ross Spur Motorway

Photo: B.I.C.C. Ltd.

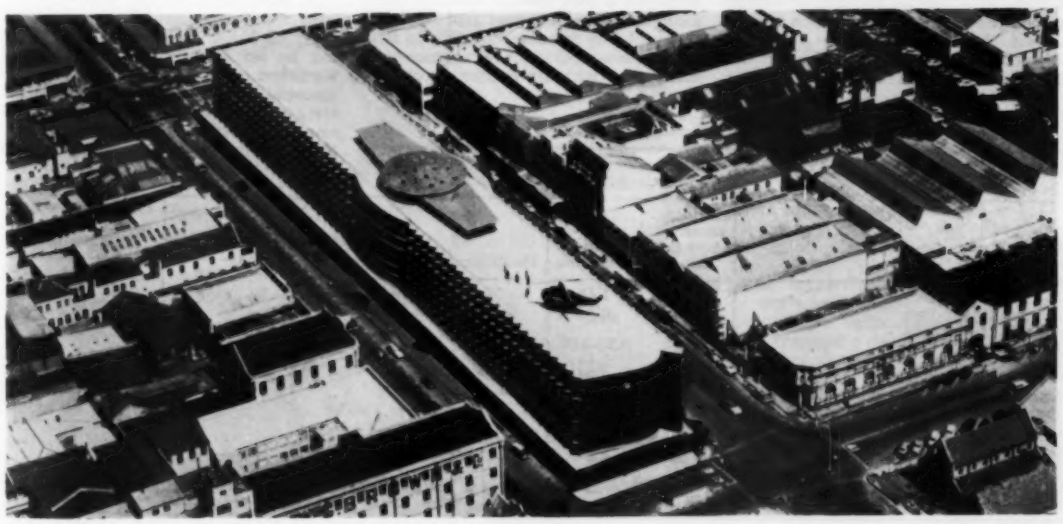
Photo: The Government of British Columbia.

Fig. 4. Malahat drive near Vancouver, B.C., a recently completed part of the Trans-Canada Highway. Further information illustrated on page 154

ILLUSTRATED

Fig. 5. An aerial view of the enlarged Stirling Corner roundabout with the Barnet By-Pass new dual carriageways at the bottom. The factories (centre) have a service road

Fig. 6. A model of the projected multi-storey parking garage in Durban, showing a heliport on the roof



SAFETY ASPECTS of MOTORWAY DESIGN

W. F. Adams, B.Sc., M.I.C.E.
Assistant Chief Engineer, Ministry of Transport

At the Traffic Engineering Study Group at the Institution of Civil Engineers on April 27, Mr. Adams presented the paper on 'Safety Aspects of Motorway Design' which is reproduced below.

THE major features of British motorway design were decided after careful study of American and Continental practice. The success of the design standards adopted may be inferred from the comparisons given in Table I.

On American toll roads the accident rates have decreased from year to year, and it may be hoped that as drivers become accustomed to motorway conditions the accident rates on our motorways will also improve.

By comparison, both with foreign examples and with other roads in this country, it will be seen that the general safety design of our motorways is satisfactory. The remainder of this paper will, therefore, be concerned mainly with special features of design as pointed by experience, which will be drawn largely from the London-Birmingham Motorway (M1 with the M45 and M10 spurs included), because no other motorway in this country is of sufficient length, and has been open long enough, for significant results to be obtained from the accident records.

To this an exception may be made: accidents on the temporary curves on the Preston and Lancaster By-Passes (M6), of some 1,000 ft. radius, have already confirmed the importance for safety of easy curvature in motorway design. These curves will of course disappear when the motorways are extended. For future temporary connections, curves of larger radius may well be considered.

Accidents on M1

The distribution of motorway accidents day by day over the first year may be summarized as in Table II.

The calculated figures in the last column are for a Poisson distribution on the assumption that the accident risk did not vary from day to day. Statistically, they are a good fit up to four accidents a day, though there is some indication of more spread than expected, due probably to some variation in risk. On this assumption the occurrence of so many days with six or more accidents would be wildly improbable, and when examination in detail is made it is found that fog, ice or snow were prevalent on the days with six or more accidents, and on some of those with five.

This means that on days with fog, snow or ice the accidents increased to between five and ten times the normal level; or, in other words, that drivers fail to take increased care commensurate with the increased difficulties.

Here it may be mentioned that three-quarters of the accidents on M1, according to an analysis made by the chief constables, were caused by mechanical or tyre failure or shortcomings of the drivers (inattention, misjudgment in overtaking, bad lane discipline, etc.) so that the field for accident reduction through increasing reliability of vehicles and improving driving behaviour is much greater than that of motorway design.

Hard Shoulders

The inadequacy of the grass-covered hard shoulders originally provided on parts of M1 is well-known, and there can be no doubt that well hardened shoulders of adequate width are an essential safety provision. Accidents were caused not only by vehicles sinking into or overturning on the shoulders, but also through drivers being deterred

TABLE I

	Accidents per million vehicle-miles		Casualties per million vehicle-miles	
	Accidents involving personal injury	All Accidents	Fatalities	All Casualties
M1 Motorway (1st year)	0.70	1.48	0.07	1.19
M6 Preston By-Pass	0.44	0.73	0	0.78
All U.S. Toll Roads:				
range	—	0.57-2.00	0.-0.14	—
average (1956)	—	1.44	0.03	—
„ (1958)	—	0.97	0.028	—
Brussels-Ostend M'way	—	1.95	—	—
Frankfurt-Mannheim autobahn ...	1.44	3.3	—	—
All German Autobahnen (1955) ...	—	3.7	—	—
All roads in G.B. (1958)	—	—	0.10	5.0
84 miles of dual c'way. (RN.2847) ...	1.60	3.4	—	—
All Trunk & Class 1 rural roads (Aug. 1958) (RN.3608)	1.5	—	0.06	2.6

TABLE II

No. Accidents	On No. Days	Calculated for 355 days at average of 1.22 per day
0	116	104.9 days
1	113	127.8 „
2	77	78.0 „
3	36	31.7 „
4	8	9.7 „
5	6	2.3 „
6	5	0.6 „
7	1	
8	1	355 days
10	1	
12	1	
13	1	
	366	

from using the shoulders by their treacherous appearance, and standing on the carriageway instead.

Junctions

The junctions of the M1 may be classified as in Table III.

Comparison of the figures in the last column is not of course entirely fair because of the different traffic volumes. However, it is unlikely that variation in traffic is sufficient wholly to account for the differences. The large difference between terminal roundabouts, partial cloverleaf layouts, and trumpet junctions on the one hand, and the remaining types on the other, will be noted.

Nearly all the accidents at terminal roundabouts have been due to drivers approaching too fast along the Motorway, and over-running the island or striking vehicles already on the roundabout. Large 'Reduce Speed Now' notices were fixed in February 1960 and appear to have produced some improvement. Nevertheless, where a future motorway terminates on a road of high speed value, a flyover type of terminal deserves to be considered, unless local circumstances and particularly the layout of the roads with which connection is made are unfavourable. Graduated curves on the approach to terminal roundabouts, provided with safe run-off areas, might be tried as a means of enforcing reduction of speed.

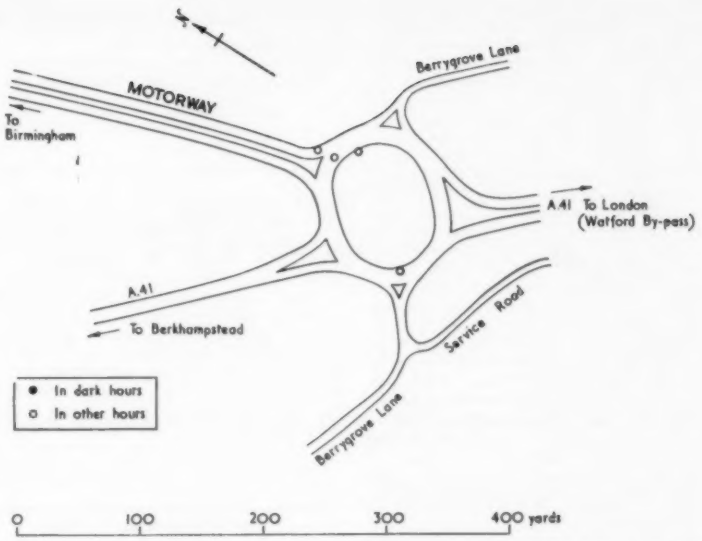


Fig. 1. Approximate position of accidents at Aldenham Terminal (A41) in period Dec. 21, 1959 to Oct. 31, 1960.

The partial cloverleaf junctions are not of wholly satisfactory design, as they involve traffic turning right in the all-purpose road to enter the slip road and also two-way traffic in the slip roads. This experience should not be taken as condemning the complete clover-leaf type of junction which has been found satisfactory in other countries. The trumpet junction at Breakspears might have been safer if constructed as a mirror image of its present form, so allowing vehicles from the motorway to decelerate along a long reverse curve to reach the all-purpose road.

The junctions of motorways, interchange roundabouts and diamond-type interchanges have proved reasonably satisfactory, except for the rapidly sharpening curve on the approach from Weedon (A45) to the Upper Heyford roundabout, where a number of drivers have misjudged the curve. A 'Bend' warning sign has been provided, but it may be necessary to improve this curve.

TABLE III

Type	Total No. of Accidents	No. of junctions of the type	Accidents per junction in first year
Terminal Roundabouts	55	5	11.0
Interchanges			
Partial cloverleaf and trumpet ...	29	3	9.7
Roundabout	16	5	3.2
Diamond	4	2	2.0
Junctions of motorways	6	2	3.0

(Accidents unconnected with the design of the junctions—i.e. those which could equally well have happened anywhere on the Motorway itself—have been excluded.)

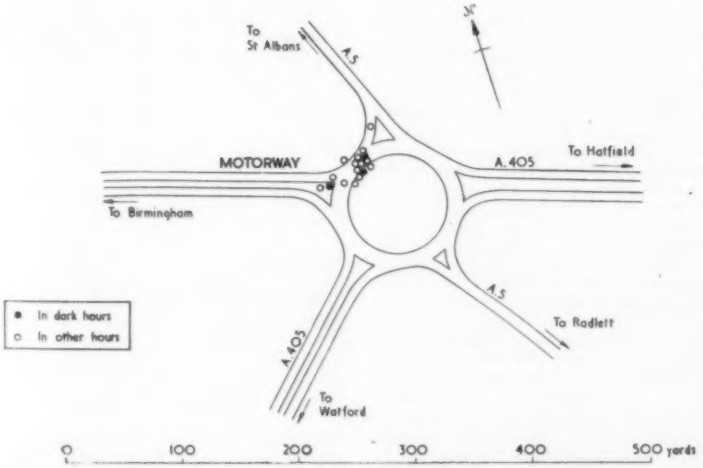


Fig. 2. Approximate position of accidents at Park St. Terminal (A5/A405) in twelve months ending Oct. 31, 1960.

Lighting

The desirability of lighting the Motorway can be discussed from several points of view, e.g. driving comfort, spreading the peaks by encouraging night travel, etc. Considered purely as a matter of economics, the losses in all night accidents on the Motorway in the first year are estimated at £71,440. The capitalized cost of installing and maintaining Group A lighting would be some £2,260,000. If lighting reduced night accidents by half, the rate of return would be only 1.6 per cent per annum. For lighting interchanges only (the terminal roundabouts are already lit) the figures would be £9,420, £720,000, and 0.65 per cent. Lighting appears hardly a worthwhile investment, particularly as the limited funds available could more profitably be used in lighting through routes in urban areas, where dangers are more substantial. There are, of course, other considerations, and if the number of night

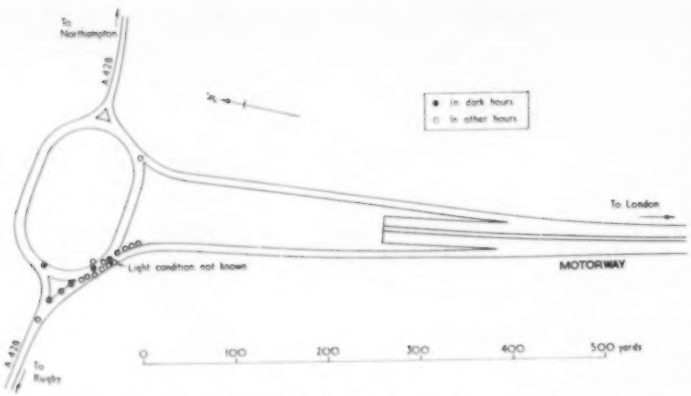


Fig. 3. Approximate position of accidents at Dunchurch Terminal (A45) in twelve months ending Oct. 31, 1960.

accidents increased very substantially the economic justification would strengthen.

Anti-dazzle Fences

Some two miles of anti-dazzle screens have been erected as a trial. There is no doubt of their effectiveness in abolishing glare from approaching head-lamps. Comparison of the accidents from the date when the screen was erected (January 19, 1960) until the end of the first year (November 1, 1960) between the screened section and the adjacent section (which carries the same traffic) as far as the next interchange to the north gives the results shown in Table IV. The Difference is negligible ($\chi^2 = 0.0025$)

TABLE IV

	Screened Section	Control Section
Number of Accidents	13	15
Length (yards)	3,515	4,147
Accidents per 1,000 yards	3.70	3.63

(The screen extends from 38 yards north of marker 34/3 to 33 yards north of marker 36/3. The control section has been taken as extending from the north end of the screen to marker 38/9).

Vehicles probably get out of difficulties by running on to the central reserve about as frequently on both sections, but where there is a dazzle screen they are likely to hit it and so become included in the accident reports. This is confirmed by Table V.

It is therefore reasonably sure that there has been a higher rate of accidents involving running on to the reserve on the screened section, but it is not yet possible to say that the reduction in other types of accident on the screened section is significant.

Casualty comparisons are not usually very reliable where small numbers are involved, because of the occasional accident which involves a number of people (two of the accidents on the control section produced nine casualties). However, there is some indication that casualties have been reduced on the screened section as shown in Table VI.

TABLE V

	Accidents involving a vehicle running on to reserve		Other Accidents		
	Screened Section	Control Section		Screened Section	Control Section
Accidents	9	3	Accidents ...	4	12
Length (yards) ...	3,515	4,147	Length	3,515	4,147
Accidents per 1,000 yards	2.56	0.73	Accidents per 1,000 yards	1.24	2.90
	$\chi^2 = 4.05$ ('Probably significant')			$\chi^2 = 2.51$ ('Not significant')	

TABLE VI

	Screened Section	Control Section
Casualties	6	19
Length (yards)	3,515	4,147
Casualties per 1000 yards	1.71	4.59

$\chi^2 = 4.85$ ('Probably significant')

Summarizing, the screened section has shown:

(1) No significant change in accidents.
(2) Significant increase in accidents involving vehicles overrunning the central reserve.
(3) A decrease not at present significant in other accidents.
(4) Possibly a reduction in casualties.

The dazzle problem on the Motorway has not proved as serious as was feared, mainly because so many drivers use dipped headlamps.

Bridge Pier Protection

Some of the bridge piers on the central reserve were provided with steel guard fences, and some with elongated concrete plinths. Fatal and serious accidents have occurred through vehicles hitting the plinths, but not where guard rails existed. The actual figures for the first year are given in Table VII.

The inference may appear clear, but caution is necessary. Statistically, the verdict is 'not significant'—it cannot be concluded with reasonable certainty that the result was not a chance effect. Nevertheless, guard fences add so little to the cost of a bridge that it would be prudent to provide them until the question is settled.

Guard Fences on Central Reserve

Guard fences have not been provided to prevent vehicles from crossing the central reserve. From the discussion on anti-dazzle screens above it appears that they might cause more accidents than they prevent. An investigation by the California Division of Highways showed that this did in fact occur unless the traffic was in excess of 130,000 vehicles a day—a figure which has not been approached on the London-Birmingham Motorway.

Out of 511 accidents on the Motorway, 58 involved a vehicle running across into the opposite carriageway, and in only seven of these was there a collision with an opposing vehicle. Three of the last involved fatal or serious injury. At best, the effect of a

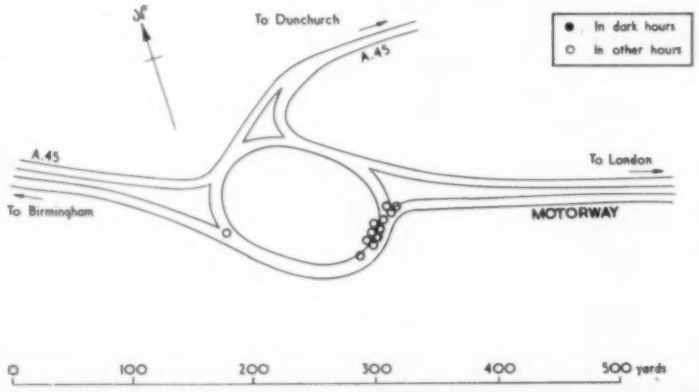


Fig. 4. Approximate position of accidents at Crick Terminal (A428) in twelve months ending Oct. 31, 1960.

TABLE VII

	ACCIDENTS				CASUALTIES		
	Fatal	Serious	Slight	Damage only	Fatal	Serious	Slight
Plinths	2	2	2	3	2	3	2
Guard fences ...	0	0	1	3	0	0	1

guard fence might have been to convert these three into slight injury or damage only accidents, and some of the remaining 55 accidents would undoubtedly have been made more severe. There might also have been further accidents caused by the presence of the fence, as already found in the section headed 'Anti-dazzle Fences', with no likelihood of a compensating reduction as found there. This increase might be of the order (2.56—0.73) × 70 miles × 1,760/1,000 yards, or some 220 accidents a year. The Motorway experience at least does not conflict with the California findings.

Bridge Piers on Central Reserve

From the above discussion on dazzle screens and central guard fences, it may well be thought that bridge piers should not be placed on central reserves. As a matter of economics, the accidents summarized under 'Bridge Pier Protection' above represent a loss of probably over £8,700 per annum, and the capitalized value may be taken as some £175,000 per annum. For the 97 bridges over the motorway this means that an extra expenditure of £1,800 per bridge would have been justified in designing them without central piers. Installing guard fences protecting the piers might well make the economic aspect less favourable than this. Other reasons, e.g., appearance, may well be stronger on future motorways than the economics of savings in accidents.

Signs

It is generally agreed that the system of signs produced by the Committee, over which Sir Colin Anderson presided, is good. Some minor alterations have been made as a result of experience, but two special points may be mentioned.

(*a*) Where two or three roads lead from the Motorway to a single town, the name of this town should appear on the signs for the best route only, otherwise many drivers turn off at the first junction at which their destination is shown, and some resent having to cover some miles of less good roads when they might have continued further along the Motorway.

(*b*) Where motorways divide (e.g. Watford Gap or Beechtree) the approach to the 'V' should be widened over a substantial distance to the sum of the traffic lanes in the diverging carriageways, and an overhead sign should be provided indicating the appropriate lane for each destination. This should encourage more orderly marshalling of vehicles as they approach the 'V'. The injunction, 'Get in Lane' is of very little use if given at a point where the appropriate lane cannot immediately be identified.

Some serious accidents have happened through vehicles out of control hitting the massive reinforced concrete supports of signs. The possibility of using lighter supports is being considered, but it is not easy to design posts stiff enough to prevent the large signs from 'flapping' in high winds.

Experience has shown need for clearer definition of margins, of edges of hard shoulders, and of slip roads at interchanges. Lane discipline is not as good as it should be, and might be helped by stronger lane markings. At the beginning of deceleration lanes weaker markings, with arrows pointing into the lane, may help to encourage drivers to enter the lane earlier than is at present done, giving more length for easy deceleration. Trials are in progress on these subjects.

It should be made clear that any views here expressed are those of the author and not necessarily of the Ministry of Transport. They are based largely on accident information furnished by the Metropolitan Police and the Chief Constables of Hertfordshire, Bedfordshire, Buckinghamshire, Northamptonshire and Warwickshire, on studies made by the Road Research Laboratory and on the work of the Traffic Engineering Committee set up, under the author as chairman, to study traffic conditions on the M1.

DISCUSSION

One of the contributors to the discussion which followed said that, while it could be seen from the figures that the accident rate on our motorways showed a considerable improvement, which was satisfactory, to those who were experienced on the Continent and on other roads in this country there still appeared to be some way to go before they reached the lower accident rates claimed in the United States. He referred to the increased accident rate on the Preston and Lancaster by-passes on the temporary curves of 1,000 ft. radius. He wondered whether it was the 1,000 ft. radius or the change from the higher standard of alignment obtaining elsewhere on the by-pass. Inevitably, particularly in the case of urban motorways where the latitude in selection of alignment was limited, radii of around 1,000 ft. would have to be accepted. This raised the necessity of some method of instructing the driver about the standard of road on which he was driving. One of the troubles arose from drivers approaching the ends of the terminal roundabouts of the motorways too fast and it became essential to indicate to the sensible driver that he should slow down to below a certain speed. On a motorway a driver was lulled into a sense of security; he relied on the designers producing a standard set of conditions, and when those conditions changed, it was essential in some way to inform him.

Looking at the problem in general, it seemed to a second speaker that the possible improvements fell under three headings. First of all, there were improvements in visibility. Secondly, in the relationship between the vehicle and the road: that related mainly to the adhesion between the tyres of vehicles and the road. Thirdly, at a later stage in accidents, there were improvements to the design of the road to minimize the consequences of accidents. One particular matter connected with visibility related to marking the edge of the road. Whether street lighting was installed or not, that was important. It was known that ordinary markings, such as white lines, were less effective in rain when colour differences disappeared, and then only texture differences gave one the contrast that one required. Research was also being carried out to find the effect of small vertical edges, such as one inch high kerb-like obstructions, on the stability of motor cars and it was hoped to find out what could be tolerated without causing serious trouble to the driver.

Another speaker said it was important that the general public, and those technically concerned, should know that the night-to-day ratio of accidents at the terminals was very much lower than it was elsewhere on the roundabouts, which corresponded with the fact that the terminals were lighted and presumably safer at night. He thought that the ratios of traffic by night and by day would be roughly the same at the two groups of places.

In replying to the final questions, Mr. Adams said that it was true that the percentage of accidents at terminal roundabouts was less by night than by day, and probably less than elsewhere on the motorway and at other junctions. It was likely that this was due to the fact that only the terminal roundabouts were lighted, so that they stood out conspicuously.

He could not give the figure for accidents per million vehicle miles on two-lane compared with three-lane carriageways, but he had made some rough calculations. He had taken the accidents on those sections and made a calculation taking the average traffic in June and July along the three-lane sections of the motorway and made a comparison with similar figures for the A45, which was a two-lane road. He had not been able to separate the figures in respect of the spur to the M10, and had, therefore, combined them. Taking the three-lane sections as 100, the following figures were obtained:

	M45	M1	M10
All personal injuries	102%	104%	—
All accidents ...	74%	126%	—

That was of some interest because it seemed to show that so far as all personal injury accidents were concerned the rate per vehicle mile did not seem to depend on whether the road was of two-lanes or three-lanes, or upon the amount of the traffic, but the figure for all accidents was quite substantially lower where the traffic density was less than it was proportionately on the three-lane sections.

He was very suspicious about breaking down accidents too far, but taking 120 as the basis, the figures were:

	M45	M1	M10
Serious accidents...	154%	40%	—
Slight accidents ...	80%	153%	—
Damage only ...	48%	144%	—

Fig. 1. Multi-storey ramp type car park constructed by Holst & Co. Ltd. for the Borough of Bedford.

HOUSING the MOTORCAR

by **J. L. Womersley,** F.R.I.B.A., M.T.P.I.

At the Annual Conference of the Town Planning Institute held recently at Llandudno, a paper was given on May 31, on the importance of providing off-street parking facilities alongside new housing developments. Extracts are given below.

GEOFFREY COPCUTT, analysing national traffic projections calculated in 1956 by K. N. Chandler of the Road Research Laboratory, concludes that if the future rise in car ownership takes the form of a straight-line graph projected from 1946, national car ownership will be 0.7 per family in 1980. Alternatively, if the more recent steeper increase continues, the 1980 figure becomes 1.4 per family. Either of these forecasts gives one car per family within the life of dwellings built today, provided that growth, prosperity and the distribution of wealth continue relative. These are important provisos, but we all recognize that the total planning effort must inevitably be directed towards increasing prosperity. Mass production of new cars will make the used car market more competitive, towards the point where some sort of car is within every man's reach.

Town planning involves an attempt to foretell the future scientifically, though in this sort of analysis it sometimes looks suspiciously like crystal gazing. However, we may at least dare to say that most families want a car, and that probably only a national disaster will prevent them from getting one in this century.

The Private Builder

There is no doubt that, given the choice, people want to garage their cars with the house. The average man is proud of his car and he wants to drive it up to his own front door; to show it off to the street; to clean it and take it to pieces in his front drive and discuss it with his neighbours over the gate—and then sell it and buy a better one. This personal involvement with the car has to be taken seriously. The car is a great family institution, and most families like to have it around the house.

The easy way out of the garage problem, for the speculative builder, is to leave a space at the side of the house and many a promising estate is ruined by the disorderly shacks which subsequently buttress up the house walls. I suggest that developers should submit fully detailed plans and elevations for the garages, whether or not they intend to build them along with the house, and that these might receive planning consent, or otherwise, as a whole. They should after all be conceived as a whole. The tremendous visual improvement that could result would more than repay any additional administrative work which may be involved.

The Local Authority

If the easy way out for the speculative builder is to leave space for a garage at the side of the house, the easy way out for the local housing authority is to leave space for grouped garages. The attendant perils are also at least as great. A block garage site has many of the less endearing potentialities of an industrial site; it can be noisy, smelly and generally offensive to residential neighbours. Many tenants' cars are kept on the road by the mechanical ingenuity of their owners, and keeping them on the road involves a good deal of maintenance. From this point of view, the worst possible arrangement is to site block garages in an extra large space left over at the backs of the houses, and then rent a bit of land to each tenant to build his own garage. Traffic noise is introduced both in front of and behind the house; gaps between garages let all the noise and smell into gardens which should be private, and the whole back area becomes a visual slum. By careful planning, local authorities can themselves build very satisfactory group garages as part of the overall estate design and let them at economic rents. The garages can be arranged in terraces in such a way that the back walls automatically enclose the gardens and give a quiet, insulated walled-garden effect. In this way, a highly civilized environment can be created, but loose or careless arrangement can so easily destroy it all and give rise to justifiable complaints. Another, and perhaps more certain way of keeping the noise of group garages from the dwellings is to build them further away with separate but convenient access to a main road, as at Cumbernauld. For all its hazards,

Concluded on page 186

Traffic Symposium

Traffic Design in Urban Areas

by J. T. DUFF,

M.Sc., A.M.I.C.E., A.M.I.E.E.

Ministry of Transport

Fig. 1. Reversible lanes controlled by overhead signal, Cincinnati.

A Traffic Symposium, sponsored jointly by the Departments of Architecture, Town and Country Planning and Civil Engineering, King's College, University of Durham, and the Roads Campaign Council, was held at Newcastle upon Tyne, April 10 to 14. Extracts from the paper presented by Mr. J. T. Duff appear below.

CONGESTION in our city centres is not a new phenomenon. But whereas congestion was formerly confined mainly to the larger cities and to certain intersections, today it is a characteristic of every town, large or small, and with few exceptions covers all the central area. Glanville and Smeed have quoted the following typical speeds for central areas:

Glasgow 8 m.p.h.
Newcastle 9 m.p.h.
Slough 10 m.p.h.
London 10 m.p.h.
Worcester 12 m.p.h.
Edinburgh 13 m.p.h.
Stafford 14 m.p.h.
Stamford 14 m.p.h.

Speeds in central areas are decreasing year by year as the following figures from Road Research Laboratory surveys in Central London show.

Year	*Average speed m.p.h.*
1949	11.4
1950	10.9
1952*	11.5
1954	11.2
1956	10.7
1958	10.3

*Removal of trams.

A high proportion of the population lives in urban areas and this is reflected in the statistics. In 1959, 48 per cent of the vehicle miles travelled on the Classified Road network was in urban areas, 35 per cent of it on the main roads, i.e. Trunk and Class 1 Roads in towns. In 1959, there were 242,000 casualties on the roads in urban areas (73 per cent of the total). In spite of growing congestion and reduced speeds however, the amount of travel in urban areas in the country as a whole has been growing at the same rate as that in rural areas (33 per cent in three years compared with 31 per cent in rural areas). In the central areas of our largest cities growth has been slower, but even at congested intersections growth has continued; for example Hyde Park Corner, which was considered to be working to capacity in 1935, was carrying 12 per cent more traffic in 1958. There are a number of reasons for this increase in the volume of traffic carried by the urban street network:

(1) Diversion of traffic to back streets.
(2) Spreading of the peak hours.
(3) Elimination of slow-moving vehicles (horse-drawn and hand-barrows).
(4) Better performance of vehicles and the greater skill of drivers.
(5) Acceptance by drivers of slower speeds and shorter headways.
(6) Traffic engineering improvements.

This list is not intended to give any indication of the relative importance of these factors. The first two help to make more efficient use of the existing capacity, whilst the others can help to create extra capacity. The possibilities of signposting alternative routes to enable drivers to avoid congested intersections was being explored by the London and Home Counties Traffic Advisory Committee as long ago as 1925 and many examples of locally signed diversions will be found throughout the country. It is probable, however, that drivers themselves achieve more by their own efforts. The spreading of peak hours by the staggering of working hours has been advocated for many years. Slow moving vehicles are gradually disappearing from the traffic scene, but in the past it has been necessary to make regulations banning them from certain streets. Waiting restrictions, one-way streets, prohibition of turning movements, improved signal control have all helped to increase the capacity of the existing street network. Further increases are still possible but in the absence of physical improvements there is a limit to what these measures can achieve.

The possibilities for increasing the capacity of the existing street network by other than physical improvements have not yet been fully realized. These measures have hitherto been applied piecemeal, often without much knowledge of traffic movements and desires and without much regard to the effect of a measure on neighbouring streets and intersections not directly affected by the changes. To estimate the probable re-distribution of traffic following, say, the introduction of a comprehensive system of one-way streets is a computer exercise which, so far as I know, has not been applied in this country. Nevertheless an intelligent appraisal is both possible and rewarding. A thorough survey of traffic, both moving and stationary, is an essential preliminary to the introduction of a comprehensive scheme of traffic control measures and to the planning of physical movements.

Apart from the more comprehensive and planned use of familiar measures, such as one-way streets, waiting restrictions and prohibition of turning movements, a number of other measures which have not been widely used are likely to receive greater attention in the future. In the first place, on important main roads and particularly in the vicinity of important intersections, bans on the loading and unloading of goods vehicles are likely to become increasingly necessary at peak hours in addition to the normal no waiting restrictions. Positive planning control can help to alleviate the inconvenience of such bans by requiring rear access to all new development.

The familiar unbalance of the directional distribution of traffic during peak hours on the principal radial routes often means that there is congestion in the direction of heavier flow and surplus capacity in the direction of lighter flow. Drivers themselves sometimes take advantage of this situation, for example by monopolizing two lanes of a three-lane road for the heavier direction. However, there has not been much done in this country to plan such operation to increase the capacity. Unbalanced flow regulations are generally only suitable for roads greater than four

Design Speed	Minimum overtaking visibility distance (single c/w.s)	Minimum stopping visibility distance	Minimum desirable curve radius	Minimum curve radius with 1 in 14½ Superelevation
m.p.h.	ft.	ft.	ft.	ft.
70	—	950	2,800	1,500
60	1,400	650	2,100	1,100
50	1,200	425	1,450	750
40	950	300	900	500
30	700	200	500	250

lanes wide. Three-lane and four-lane roads only permit a single lane for the direction of lighter flow, so that slow vehicles or one setting down or picking up passengers retards the entire flow and a vehicle breakdown blocks the traffic completely. The four-lane road in particular requires the unusually high ratio of 3-1 in the directional flows. On five-lane and six-lane roads, however, the allocation of three or four lanes respectively to the direction of heavier flow, leaving two lanes for the lighter flow, is generally an efficient arrangement. There is a practical difficulty in introducing tidal flow arrangements in British streets arising from the extensive use of pedestrian refuges. An American example is given in Fig 1.

The capabilities of modern vehicle-actuated signals are not fully appreciated by many engineers. The capacity of existing streets is generally governed by the capacities of the intersections. More efficient signal control with minor changes in road layout will increase the capacity of the intersections. At small roundabouts the addition of signals to control the entry of traffic into the roundabout can increase the capacity. The idea that controlling the input to a bottleneck can increase its capacity is something of a paradox to many people but it is definitely possible and the principle can be applied to a number of situations. Examples of different types of intersections are given in Figs. 1-5 below.

For the planning and designing of new roads it is essential to have forecast estimates of the traffic volumes for which provision should be made. In rural areas it is customary to use for design purposes the average daily traffic (7-day average—6.00 a.m.-10.00 p.m.) during the peak month of the year. The generous figures for design capacity make adequate allowance for hour-to-hour variations within the average day. Where possible, ring roads and by-passes inside the urban boundary should be designed to rural standards, but nearer the centre where property acquisition becomes difficult and expensive it is necessary to design to higher capacities which leave less margin for above-average flows. In these circumstances it is essential to design on the peak flows and not the daily average.

The rate of growth of traffic in urban areas has been no less than that in rural areas and there is no reason for supposing that future growth will be any less where provision can be made for it. Wherever possible, therefore, provision should be made for a future growth of five per cent per annum compound in passenger car units. The design of roads in urban areas is however essentially a matter of economics and there may well be a sound economic argument for designing for a lesser rate of growth in particular circumstances.

In addition to design to higher capacities, further economies in urban areas can be achieved by utilizing lower design speeds and lower standards in respect of cross-section widths. Where possible the 12 ft. running lanes recommended for rural areas should be adopted, but for design speeds of 30 or 40 m.p.h. 11 ft. running lanes would normally be acceptable. For urban motorways peak hour capacities of 1,500 passenger car units per lane for the direction of heavier flow are reasonable but obviously result in lower speeds than on rural motorways. When volumes are high, the speeds are automatically lowered but a speed limit may be necessary on these roads to deal with light flow conditions, since the driver may not be aware that the road has a lower design speed than the rural motorway which will probably form the continuation outside the urban area.

For all-purpose through roads subject to 30 m.p.h. speed limit, design capacities of 10,000 passenger car units per day can be used for two-lane roads on which waiting is prohibited or provided for by an extra parking lane. The design capacity of 25,000 passenger car units per day for a two-lane dual carriageway should not normally be exceeded unless the road is to motorway standards or waiting is to be strictly prohibited.

The lower design speeds permit of reduced standards for visibility and curves as shown in Table above.

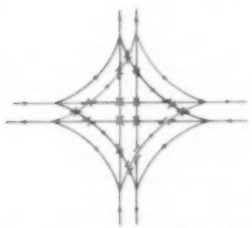


Fig. 1. Direct Connection with Multi-level bridge.

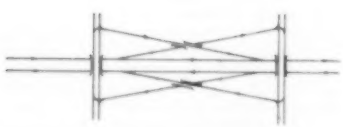


Fig. 2. Diamond Layouts with Braided Ramps.

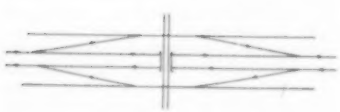


Fig. 3. Diamond Layout with parallel-service roads.

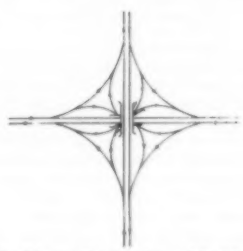


Fig. 4. Direct Connection with Multiple bridges.

Fig. 5. Diamond Layout.

Traffic Symposium

The papers, and discussions that followed their presentation to the Symposium on Urban Survival and Traffic held at King's College, Newcastle upon Tyne, University of Durham, April 10-14, 1961, will be published in full in the Volume of Proceedings which is now in preparation and will be published later this year by E. & F. N. Spon Ltd.

NEXT MONTH'S

contributions include

TRAFFIC GENERATION OF CENTRAL BUSINESS DISTRICT LAND USE

H. M. Edwards & B. S. C. Harper
Queen's University, Kingston, Ontario

ASSISTANCE FOR ROADS IN UNDER-DEVELOPED COUNTRIES

Christopher Brunner
Chairman, International Road Federation

EDINBURGH REGION TRAFFIC SURVEY

G. M. Dickson
City Engineer's Department Edinburgh

TRAFFIC ASPECTS OF URBAN INTERSECTIONS

Baurat Dipl.-Ing. Hanskarl Schreiner
Traffic Engineer, Essen

SAFETY STRAPS FOR CARS

Brig. R. F. E. Stoney
Director-General of RoSPA

SIGNAL MAINTENANCE

Fig. 1. Specially equipped van testing a vehicle-actuated traffic signal.

TRAFFIC signals in this country are predominantly vehicle-actuated and, having been developed by companies experienced in automatic telephone switching techniques, make use of similar circuit elements with their proved reliability. Traffic signal equipment, however, has to operate under conditions far more arduous than those prevailing inside a telephone exchange because of variations in temperature and humidity and the inevitable ingress of dust. It also has to work 24 hours a day year in and year out.

In busy urban areas traffic is now so heavy that many intersections are working close to saturation point, and it is more than ever necessary to maintain precise time settings at each to promote a smooth traffic flow throughout an area. A fault at one intersection can have far-reaching effects and it is essential for all the signals in an area to be maintained to the same high standard.

With the growing complexity of traffic signal equipment as more and more facilities are incorporated, such as speed timing, variable minimum green periods predetermined by the number of vehicles arriving during the preceding red period, variable all-red periods and various forms of linking, it becomes increasingly difficult for a layman to know whether an installation is working correctly or not. It is, therefore, necessary to employ specialists and this fact, together with the need to carry a wide range of spare parts and spare controllers to give quick service in the event of a fault, influences most local authorities into placing the responsibility for maintenance with the manufacturer of the equipment.

Automatic Telephone & Electric Company, who originally introduced the vehicle-actuated type of traffic signal in 1932, maintain practically all the signals they have supplied in this country since that date. Service is provided from nine depots located at London, Belfast, Glasgow, Edinburgh, Leeds, Manchester, Liverpool, Birmingham, and the Channel Islands. Almost half the total number of signals are in the London area. Each depot is supervised by a Regional Maintenance Officer who is responsible to the Chief Maintenance Officer in the Company's Traffic Signal Division in Liverpool.

Maintenance work falls under two headings:

(*a*) Preventative maintenance, which involves regular routine inspections to anticipate the occurrence of faults.

(*b*) 'Beck and Call' service to correct faults as they arise.

The more efficient the first can be made, the less need there will be for the second; and it has been found by experience that a quarterly inspection is the best compromise.

A depot's area is divided into sub-areas each under the control of a particular faultsman. This encourages the men to take a pride in their workmanship and introduces a modicum of competition which increases their efficiency. It also enables the Regional Officer to locate any man who is below standard so that he may be given further training; and it promotes personal relationship between the faultsmen and the customers. The number of intersections in each sub-area is qualified by the technical complexity of the particular controllers and by the distance of the intersections from the depot. It is desirable to restrict the time taken for a tour of routine inspections to approximately a month to keep sufficient men available at the depot to provide an efficient beck and call service.

So far as is possible, faultsmen attend personally to all faults in their particular sub-areas, but when this cannot be arranged, only the best men are allowed to work in another's territory. Good faultsmen are difficult to find as they require a high technical skill yet must be prepared to work under unpleasant climatic conditions, and to turn out at short notice at any hour.

The system can best be described by giving a typical example of an area capable of being covered by three faultsmen. The depot is located in the area of greatest density and divided into three sub-areas, for instance north, south and local. Faultsman A is assigned to the north, B to the south and C (the best man) to the local sub-area.

Faultsman A starts on his tour of inspections and takes about a month to complete his circuit. Each day he telephones his depot at an agreed time and receives instructions concerning any faults that may have occurred in his immediate vicinity so that he may interrupt his tour temporarily to attend to them. Faults in his area which are not in his immediate neighbourhood are dealt with by faultsman C. A similar arrangement is made when faultsman B is on tour. Faultsman C, being local, operates daily from the depot when carrying out his inspections and so is able to maintain continuous contact and deal with all faults in his area.

Large vans equipped as mobile workshops are used for a tour. These carry a faultsman and a fitter, the former being in charge, and sufficient spares for all normal repairs including those to detectors. (Fig. 1.)

The heavy traffic in large towns makes it impossible to carry out work on detectors during normal hours, and because of this and the difficulty of parking large vehicles, light vans are used in such areas, carrying only a faultsman who notifies his depot of any detector work required and it is done by fitters at quiet traffic periods.

Regional Maintenance Officers must be able to advise any of their men who find themselves in difficulties, and are usually recruited from among the best of the faultsmen. One of their important duties is to keep in touch with customers and advise them on all matters affecting their signals, except major alterations or new installations, which are dealt with by the Company's Survey and Planning Department.

The duties of the Headquarters staff at Liverpool, in addition to the usual administrative functions associated with the day to day running of a large department, include recording systems designed to reveal any weakness in the equipment or in the maintenance service provided by the maintenance depots. A record card is kept for each installation giving full details of the equipment fitted, the facilities provided, the controller timings etc. This is kept up-to-date if any alterations are made to the intersection.

With this card are filed reports from the depot concerned on every visit made. These reports, as well as describing the reason for the visit and the work carried out, show the time taken and the material used so that the cost may be ascertained. Reports also show the time and date of receipt and clearing of the fault to enable the efficiency of the beck and call service provided by the depot to be assessed. The record card with the associated visit reports give a complete history of an installation from the time it is put into service. Before filing, each report is read by an experienced engineer to check that the work described is reasonable and that the 'clear' given for a fault is sensible.

The faults per month in each depot area are counted and the average number of faults per week per hundred intersections is calculated and sent monthly to all depots. A fair comparison can thus be made between the fault rates in different areas and the reason for any marked difference can be investigated. Reports covering routine inspections are extracted and the dates entered on a separate card index which is arranged to show whether all inspections are being completed each quarter. The reason for any omission is investigated.

Finally, an analysis of all faults is made to ascertain:

(*a*) Whether the fault rate at a particular intersection justifies a special examination of the equipment there.

(*b*) Whether the prevalence of a particular class of fault warrants re-design of that part of the equipment.

An analysis card is kept for each intersection upon which is tabulated every variety of fault that commonly occurs, with spare columns for exceptional faults to be entered. When a repair of any kind is made at an intersection, either as the result of a fault call or during a routine inspection, details are taken from the report and entered in the appropriate column, temporary repairs being indicated as such. When the card is next referred to the number of faults which have occurred since the last routine inspection is noted and if this exceeds two, the history of the installation is examined to decide whether any special steps are necessary. Repeat faults are pointed out to the depot concerned and a follow-up kept. At the same time it is checked that any temporary repair previously done has been made permanent. Each fault or repair entered on the individual analysis card is also recorded on a summary card in the form of a pillargraph which emphasizes predominant faults. The totals so accumulated are examined monthly and if any class of fault shows an increase an investigation is made.

The system is invaluable for revealing any weakness in newly designed equipment, and enables any necessary modifications to be carried out with a minimum of delay. The monthly fault analysis is circulated to all depots who are also kept advised of any point of interest that arises in connection with the work of the organization or matters related thereto.

The number and variety of spares used annually is very great, and comprehensive stores records are required to ensure that they are available. Each depot holds its own stocks, which are fed from a main stores at Headquarters, and stock-taking is done once a year to enable the usage of each item to be calculated. In the case of detector materials, as a summary of the number of detectors fitted is kept up-to-date, it is possible to ascertain the average life of the various items by comparing the annual usage with the total number installed. This gives a very accurate measure of the reliability of detectors year by year. Depots hold a sufficient variety of spare controllers to cover temporary replacement of almost all the working controllers in their area to permit the latter to be overhauled in the depots etc. Where a particular type is comparatively rare, one or two depots will have spares, and the remaining depots are kept advised of their whereabouts and can borrow them in case of need.

Fig. 2. Inside the testing department at the London depot of Automatic Telephone & Electric Company. (Photo by Morgan-Wells.)

Almost all journeys are made by van, nearly 600,000 miles being covered in 1960, and records are kept to compute the running cost and condition of each vehicle.

An efficient maintenance service implies not only keeping equipment in working order, but also analysing the causes of failure and striving to rectify any weaknesses in design. Comprehensive statistics are essential to enable intelligent anticipation of trouble to reduce service failures to a minimum.

This article was prepared for Traffic Engineering & Control *by the Automatic Telephone & Electric Company.*

PARKING *Concluded from page* 182.

the reserved group garage site is such a convenient way of dealing with a slow build-up of future applications for car storage spaces that few authorities will be able to manage without it.

Other alternatives are to provide roof shelters only, euphemistically known as carports, which are cheaper than garages, or simply to accept open-air parking lots, which are the cheapest of all. But these solutions do not save much land, and you might just as well build garages if car owners are prepared to pay the rent for protection from the weather, from damage and from theft.

Multi-Storey Garages

If land is scarce and dear, it may prove worth while to subsidize multi-level garages in the same way as additional subsidies are made available for multi-storey flats.

In the Barbican layout, by Messrs. Chamberlin, Powell and Bon, most of the site was already deeply excavated by the cellars of bombed houses and offices, and two levels of covered car parking are to be established below ground. This is an ideal solution in high density building, because the garage roof can be used for play spaces and amenities of all sorts, and visual problems are minimized. Put your multi-storey garages in a hole if you can find one. When building multi-storey slab blocks in redevelopment areas, it may be economical to dig out a complete basement floor on your way to a good foundation; you might just as well leave it excavated and store cars down there. For the flat dweller, a garage at the bottom of the lift shaft is the equivalent in convenience of the garage within the curtilage of the house.

At Norfolk Park, Sheffield, another site of severe slopes, provision was made for car spaces in a multi-level podium at the base of the point blocks, serving nearby houses as well as the point block flats themselves.

Our researches into the layout at Norfolk Park showed very clearly that provision of 100 per cent car storage within the life of the estate must seriously affect layout where densities are above 100 persons to the acre. The percentage of ground taken up with car parking obviously must increase with density, given single-storey ground-level parking. At 100 persons to the acre, a quarter of the ground would be covered by one-storey garages, an eighth by two-storey, and a twelfth by three; at 200 persons to the acre, half the ground would be covered by single-storey garages, a quarter by two-storey garages, and a sixth by three. Now grass, trees and playgrounds are vitally important in high density layout, and if we are not to sacrifice them it seems clear that either the upper maxima of acceptable density must be lowered, as garage provision is increased, or substantial, additional cost must be incurred in providing for the multiple use of land for cars, gardens and recreation space.

New Publications

Planning Research. The Town Planning Institute. 18s. 6d. net, 20s. post free.

Over the last few years, the Town Planning Institute has been preparing a Register of Research done in the field of town and country planning. The results are presented in this valuable document which comprises a list of the work done between 1948 and 1958 under a number of headings stretching from land resources and their use and conservation, to national parks and access to the countryside, taking in a vast number of subjects which cover the field comprehensively. The work is completed with an introduction on research and the development plan by F. J. McCulloch, Assistant County Planning Officer, Lancashire County Council, and with a directory of Research Institutions and an Index of research workers, contributing bodies and a list of planning officers. The Institute is to be commended for its enterprise in undertaking this unique venture which, it is believed, is the first of its kind as far as the compilation of research work undertaken in any particular field is concerned. The difficulties encountered are evidenced by the gaps which are inevitable in a pioneer venture, but it is hoped that these will be closed when the revision of the work, which is envisaged as a continuous project, is made in the next two or three years.

The sections dealing with transport and communications, in general, and roads and road transport, in particular, are regrettably sketchy. This is no fault of the compilers, who were depending upon research bodies whom they invited to provide the relative material. Unfortunately, it appears that the Road Research Laboratory considered the work they had undertaken during this period so extensive that it could not be readily or usefully summarized to meet the requirements of the Register. This is understandable, but it might have been expected that a selection could have been made of the more important aspects of their work which were strictly relevant to planning, which after all is incomplete unless it embraces transport which is so closely tied to land use. The deficiency is not fully made good by the summary of the field which the Road Research Laboratory covers in the Directory of Research Institutions, useful as this is. It is true the Road Research Laboratory publishes a list of its publications but it is to be hoped that either the example of the Town Planning Institute will be followed by those responsible for research in the field of transport, including roads and traffic, or a similar register will be compiled covering that field.

Meanwhile, this Register of Planning Research will be of lasting interest and value to all concerned with town and country planning as it signposts them to the bodies which are undertaking the work in any particular field where information is sought.

Fig. 1. General view of town centre 'Motopia.' The entrance fly-over crosses the car park above the railway station and ascends to roof level. Branches serve the railway and rear of shops.

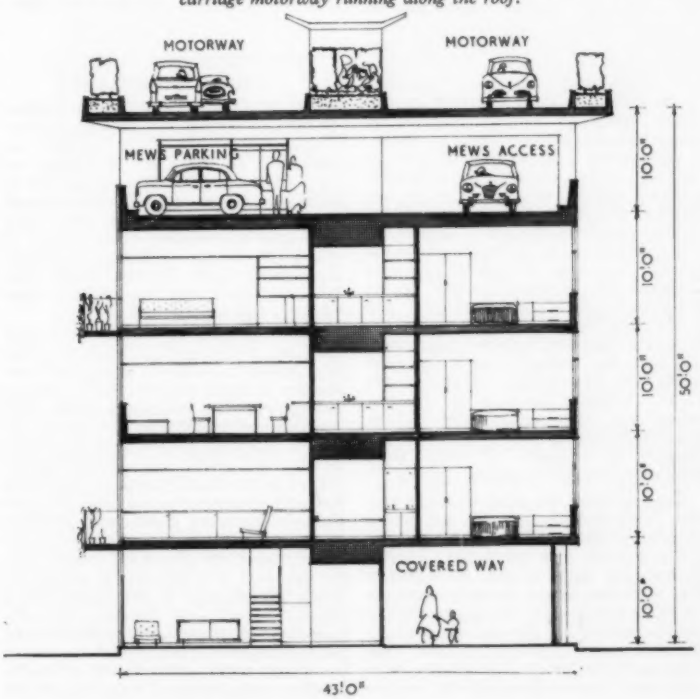
MOTOPIA. A Study in the Evolution of Urban Landscape by G. A. Jellicoe. Studio Books. 42s.

THIS is a fascinating exercise in creating an ideal town in relation to the landscape it occupies. The imaginative enterprise was initiated by the Glass Age Development Committee of Pilkington Bros. Ltd., and carried out by a team of which the chief designer was June Colwill. The objective is to provide a pleasant environment in which it is possible to live with the motor car without suffering from the noise and ugliness that has accompanied its advent in urban areas. It is sought to achieve this by segregating homes from traffic and pedestrians from vehicles by elevating the roads and keeping the vehicles away from the centres of social activity: in sum, in liberating the urban dweller from the appalling circumstances which, the author contends, modern man has created for himself. In Motopia there would be three levels of traffic, with parking at the highest level and continuous pedestrian lifts plying between the car parks and the shopping arcades which would be on two levels. Flyovers from the access roads cross the car park and ascend to roof level. (Fig. 1.)

Unquestionably, those responsible for the project display the most fertile imagination but how their theories would develop if carried into practice and whether man, accustomed to the variety, if inconvenience, of modern life, would be content with this ideal city with its monotonous repetition of straight lines and circles is doubtful.

For the production with its mass of well selected and beautifully reproduced illustrations of landscape and architecture there can be nothing but praise. No-one can turn its pages without experiencing a sense of pleasure that so much beauty exists and only regretting that so much ugliness goes with it also.

Fig. 2. Section of a residential terrace showing the covered pedestrian way running underneath the residences with the mews access to parking on the top floor and the dual carriage motorway running along the roof.



The Cost of Roads. Political and Economic Planning. Vol. XXVII No. 452. 3s. 6d.

In their customary manner, P.E.P. have produced a generally sound and wide ranging study, this one being concerned with the economic questions raised by our road and transport problems. After considering the growth in the number of road vehicles, the importance of road transport in the economy, and our road system and expenditure in comparison with other countries, the pamphlet considers the adequacy of present road plans and the criteria by which investments may be judged.

Here we are on controversial ground for P.E.P. hold that, because the user of a commercially priced service has to pay for that service specifically, whereas the road user does not, benefits and rates of return from road schemes (which include those to users who may not be willing to pay commercial prices for road use) tend to be over-estimated as compared with commerical rates of return. Although the question raised is important and needs to be resolved, not everyone would agree with this interpretation because in the taxation he bears the road user is paying a price for his road use which (for rural schemes at least) may be more than adequate.

Public policy towards transport, and the question of public versus private transport, are discussed in some detail in view of the space saving characteristics of public transport and its effect on road traffic volumes. The pamphlet holds that in spite of the heavy taxation of the road user and neglect of the roads, public transport (because of restrictions and lack of investment) has been at some disadvantage vis-à-vis the private vehicle, and prevented from realizing its full potentialities. It suggests, therefore, that the increasing use of private vehicles should not be regarded as an inevitable trend to which road policy should be adjusted, and advocates as an alternative the subsidization of public transport schemes, such as the Victoria Line, which may be well worth while in terms of relief of congestion, but not commercially viable.

Concerning the weight of general taxation of the road user, the pamphlet suggests that it is impossible to say whether this is too high or too low but, turning to taxation as a means of regulating road use, there is support for specific charges (including parking charges) in congested areas where congestion costs imposed by the individual user on the other users are high, but there are no details of practical schemes for imposing such charges. Tolls on motorways, however, are rightly opposed because of the low congestion costs attributable to the individual vehicle and because of the dangers of transfer of traffic from motorways to more congested roads.

On priorities for road development, the study emphasizes the haphazard nature of the road investment programme and the need for further information and research. It considers that there has been too much emphasis on rural motorways, which are held to benefit mainly the private motorist, to the detriment of urban schemes that might give higher rates of return than, say, the London-Birmingham motorway. But it recognizes the danger of traffic generated by urban schemes which might negative much of their potential benefit and suggests that if urban motorways are to be built, they should be accompanied by restrictive measures and measures to maintain public transport systems. Finally, under the familiar heading 'Co-ordination of Transport', the report questions the construction of rural motorways because of their duplication of rail routes and again supports urban schemes, but on the rather dubious grounds that these will benefit both road and rail transport.

In its conclusions, the study emphasizes the neglect of the roads and of road research but stresses that solutions should be sought, not only in increased investment, but in making better use of existing facilities, particularly in urban areas where the advantages of railways and the dangers of road investment without restrictive measures also, are obviously thought to be very strong.

Although for the highway and traffic engineer the report must be regarded as controversial, P.E.P. are in fact to be congratulated on raising, in a reasonably open and objective way, three points of controversy which are likely to dominate road discussion in the 1960s, viz. public versus private transport, restrictionist versus expansive solutions, and urban versus rural road schemes. In spite of some apparent inconsistencies in the arguments used, and the neglect of the practical difficulties of some of the policies advocated, this study should not be ignored.

D.J.R.

Korte, J. W. (1961) Grundlagen der Strassenverkehrsplanung in Stadt und Land: Second Edition (Bauverlag, GMBH, Wiesbaden, Berlin).

Professor J. W. Korte, Director of the Institute of Town Planning and Traffic, Technical University, Aachen, with the assistance of Dr. P. Mäcke and Dr. Lapierre, wrote this comprehensive book on 'Fundamentals of Road Traffic Planning in City and Country' in 1958. In 1960 the Second Edition was produced and the rapid development which has taken place in traffic engineering during these two years has been fully accounted for. The first edition of the book had 531 pages; the second edition has 766, this increase giving an adequate measure of the up-to-date cover of the new edition. The chapters are as before:

(1) Town and Country Planning.
(2) Traffic in City Planning.
(3) The Nature of Road Traffic.
(4) Traffic Surveys.
(5) Working Methods in Traffic Planning.
(6) Constituent Elements of Road Traffic Plans.
(7) Examples.
(8) Contributions to Traffic Research,
(9) Public Transport.

Within the chapters there have been valuable additions since 1958. For example, in Chapter 2, the question of future development in traffic within cities is discussed with special reference to the mobility of city dwellers. Chapters 3 and 4 discuss the influence of speed and safety, and in Chapter 5 the causes of traffic accidents are reviewed. Chapter 6 probably contains the most valuable part of the book, dealing as it does with the layout of streets and intersections. The preparation for this study is given in earlier chapters, especially in the comprehensive sections 'Traffic Diagnosis' and 'Traffic Therapy'.

The book is beautifully produced, and covers all the modern fields of traffic engineering. To those who read German it will prove an excellent reference text, with its 517 illustrations as well as the uncounted examples Prof. Korte offers from many parts of the world.

W. Fisher Cassie

MUNICIPAL ENGINEERING WORKS EXHIBITION

THE Institution of Municipal Engineers, in connection with its Annual Conference at Brighton, staged an exhibition in the Corn Exchange on June 13, 14 and 15. The Exhibition of Municipal Engineering Works consisted almost entirely of models, plans and photographs covering every aspect of the work of local authority engineers throughout Great Britain. More than 50 local authorities had displays, and Holland was represented also.

Although the Exhibition was not confined to any particular aspect of the Municipal Engineers' work, and examples of town centre redevelopment, sewage systems, housing schemes and sea defence works were displayed, the accent had been most heavily placed on urban and rural road construction. There were only a few stands which had nothing on show covering this particular subject. Some of these road schemes were comparatively straight-forward, for instance the design of a new road bridge over the railway at Brighton, while others usch as the Cumberland Basin Scheme in Bristol, the reorganization of traffic at the Birkenhead side of the Mersey tunnel and Norwich's road and traffic plans based on traffic studies, well displayed with the relevant diagrams and reports, and urban road proposals in Durham were on a very different scale.

From Holland came a display of photographs and plans of the whole range of municipal engineering works: Amsterdam, Maastricht, The Hague and Rotterdam were well represented. All the stands, including the Dutch, had engineers present to explain and discuss their display.

From the traffic engineering point of view the Exhibition had considerable interest, but it would have been of greater value if space had permitted the display of more data to explain how or why the proposals had been put forward and accepted.

The Exhibition was staged as much for the general public as for experienced and knowledgeable viewers and where space permitted a few signs of the relevant data would have greatly enlarged both the interest and the instructional value of the exhibits. Among the few traffic control devices displayed, of particular interest was the working model of Brighton's Clock Tower Traffic Signals Extension designed by traffic engineers in the Borough Engineer's Department. An article on this unique scheme will be published in an early issue of *Traffic Engineering and Control*.

N.A.K.

LIGHTING and ROAD SAFETY

by F. BÄHLER,
Engineer, Bernische Kraftwerke AG. (Berneese Electric Power Co.)

Fig. 2. Lighting by high pressure 250 watt fluorescent mercury lamps enabling the light to be radiated asymmetrically.

ROAD traffic by night has increased by leaps and bounds in the course of recent years. The causes of this increase, whose development it is hard to determine with any certainty, can be recapitulated as follows:

Rapid development of motorization in all classes of the population.

Very much more frequent use of motor vehicles during hours of darkness when there is little traffic about, to save time owing to higher possible speeds at night.

The tendency, which is becoming more and more marked, to spend the evening elsewhere than at home (local evening traffic).

More frequent use of motor vehicles during the winter months, i.e. the season when nights are long.

Unfortunately, this trend has its bad side as well. Statistics show that in Switzerland more than 40 per cent of the accidents occurring inside and outside built-up areas occur during the night. This proportion is particularly high when it is remembered that traffic throughout a night only represents about 15 per cent of the mean traffic during 24 hours. Furthermore, statistics demonstrate that the results of night driving accidents are as a rule more serious than those taking place in daylight. Compared with the total traffic during 24 hours, the frequency of night-time traffic accidents is more than three times as high.

Good local street lighting is certainly the best means of increasing very appreciably the safety of traffic at night. A number of enquiries in Switzerland and abroad have shown that a good lighting installation, without simultaneous road correction, can reduce the number of accidents at least from 25 to 40 per cent. This finding clearly demonstrates the utility and urgency of good road lighting.

What is to be meant by good road lighting? A road can be considered well lit when traffic can use it as rapidly and safely after nightfall as during the daytime. Therefore, the important thing is to create an atmosphere of lighting making it possible to see reliably and rapidly the obstacles and dangers at a fairly great distance and to estimate with the greatest possible safety factor the speed of approach or departure of any object. To achieve this aim, certain conditions have to be complied with and can be described as follows:

(1) *Sufficient local uniformity.* This is an essential requirement in planning a modern installation, for dark zones in the continuous lighting of a highway represent a not inconsiderable danger to drivers of motor vehicles. Local uniformity is above all determined by the ratio between the height and spacing of the lighting points. When reflectors placed in the form of a quincunx are used, this ratio should be about 1:3, at most 1:3.5. Over and beyond this figure the uniformity of lighting on the highway is dependent on the light distribution curve of the fixture, likewise on the nature and state of the road surface.

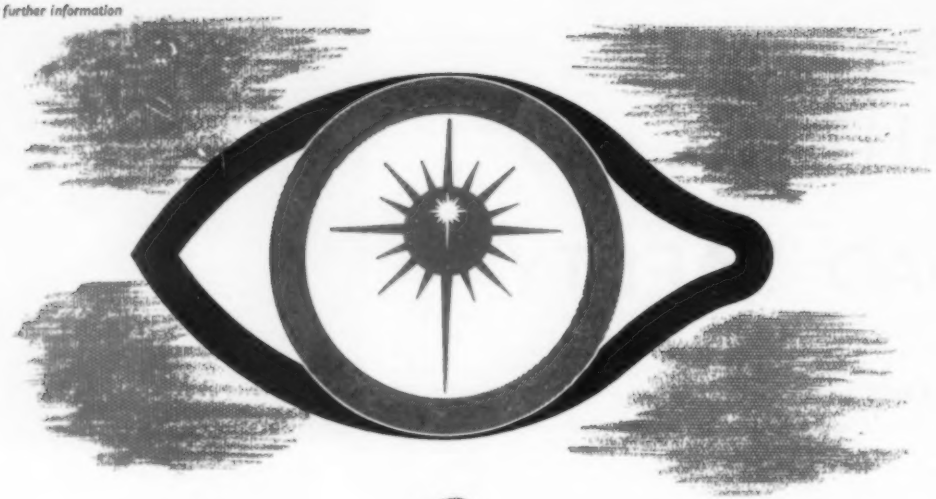
(2) *Necessary level of illumination.* The level of illumination must be such that even a middle-aged driver, whose sight has deteriorated, can see obstacles dependably over large distances. In the case of roads with a bitumen surface, where traffic is slight or average and asymmetrical reflectors are placed at a height of 10 m., a specific luminous flux of 30 lumens per square metre (lm/sq. m.) is allowed for. This minimum figure corresponds to a mean illumination of about 5 lux (lx). When traffic is heavy or the road representative, the mean illumination should amount to 10, 20 lux and even more. These figures are for the state of operation of the installation, i.e. allowing for deterioration of the source of light or dust settling on the installation (mean decrease in the level of lighting after two years is about 50 per cent).

(3) *Elimination of direct glare.* Glaring road lighting causes a weakening of the visual capacity and engenders insecurity and fatigue in the driver. Sources of light should therefore be provided with lateral screens or shields and placed at a sufficient height (for the continuous illumination of the highway, at least 9 m.; at squares, 10-16 m. above the ground). It is important not to confuse direct glaze with the bright reflection bands caused by fixed lighting on wet streets. Wide, blurred reflection bands are not undesirable, for they often represent the only means of seeing obstacles silhouetted against the dark, wet surface.

The choice of the source of light constitutes a special problem, which has been much discussed recently in specialist circles. Indeed, opinions often diverge, both in Switzerland and abroad. Whereas in France use is made above all of mercury lamps with colour corrected light (fluorescent bulbs), in the new installations in Holland, sodium vapour lamps predominate, and in Germany tubular fluorescent lamps. In view of the building of national highways, it would doubtless be desirable if there were co-ordination of opinions as regards the use of sources of light of a modern type in Switzerland. The following brief description of modern lamps can only furnish an approximate idea of their technical properties, and what is said regarding their application is only indicative of the general trend to be adopted.

The fluorescent mercury vapour lamp has an average life of about 9,000 hours for street lighting. It is made with outputs of 50 to 2,000 watts, and a 250 watt type has a light output of about 43 lumens/watt (1m/W), including losses in the control gear. The relatively small external dimensions of this lamp enable it to be installed in fittings which are not unduly large and therefore moderately priced. Moreover, the spectral composition of the lamp, which is sufficient for the application in question, the long life and the good light yield have made this source of

TEC550 for further information



OPTICAL SCIENCE IN STREET LIGHTING

By controlling the distribution of light within strict, predetermined limits, HOLOPHANE refractors and reflectors provide the ideally flexible medium for modern street lighting projects. The full range of HOLOPHANE refractors and lanterns covers all needs for both Group 'A' and 'B' roads, with many different designs to overcome specific problems of siting and light distribution.

Consequently, light sources can be scientifically applied to simulate an unbroken surface luminance with adequate background brightness.

HOLOPHANE units are constructed to unique prismatic designs fully controlling the lamp output and embodying the detailed optical research of HOLOPHANE scientists for over sixty years.

Please write for details of the complete range of HOLOPHANE street lighting units.

HOLOPHANE LIMITED

SCIENTIFIC ILLUMINATING ENGINEERS

ELVERTON ST. WESTMINSTER, LONDON, S.W.1

'Phone: VICtoria 8062 'Grams: Holophane, Sowest, London

light the type most in use at present in Switzerland for new installations. It is well suited to the lighting of main and second class roads in villages and towns and even outside built-up areas. There is a certain drawback to it, residing in the fact that if there is a current failure, even a very short one, it takes several minutes for the lamp to relight.

Sodium Vapour Lamps

The improved sodium vapour lamp, which has recently been marketed, is the source of light having the highest output, viz. about 90 lm/W, including losses in the dispersion field transformer (200 watt types). It is made with power consumptions from 45 to 200 watts and has a average life in operation of about 5,000 hours. The exclusively yellow, i.e. monochrome, light, is above all suitable for large inter-urban traffic arteries and motorways. On sections lit by means of some other source of light, the sodium vapour lamp is also employed for marking very clearly dangerous crossroads, level crossings etc. In this case, traffic signals must also be lit in addition with the aid of some other source of light so that their colour can be recognized. In residential areas, the sodium vapour lamp has also been used for some time in conjunction with the fluorescent mercury lamp and there is thus obtained what is termed 'mixed light'. It is clear that this solution combines the technical running properties of both lamps, i.e. their advantages and disadvantages. Owing to the low pressure at which it works, the sodium lamp lights up again at once after a brief interruption in the current.

The tubular fluorescent lamp is mainly represented for public lighting by 40 watt types (and sometimes also 20 and 65 watt types). The light output is about 55 lm/W (including ballast) and the working life is 7,500-9,000 hours and more. Owing to the tubular shape, the reflectors direct the light emitted rather less well. In view of the low power units per lighting point, several lamps are needed to obtain a sufficiently high level of lighting. The fittings are therefore larger, more costly and, owing to the working properties of the lamp, have to be provided with a heat insulation enclosure, generally of perspex. Thanks to the excellent spectral composition of the light, which enables the colours to be given their natural hue almost perfectly, this lamp is chiefly suitable for urban installations where pedestrian traffic is intense and in all busy centres. After current breaks, the fluorescent lamp relights at once. The light performance of the discharge lamps described holds good for new lamps, i.e. after a hundred hours' operation; as the source of light becomes older, it decreases little by little, down to 75-80 per cent of the initial value.

The incandescent 'S' type lamp for road lighting is designed for a useful life of about 2,500 hours. The light yield of a 100 watt lamp is 11 lm/W (200 W = 13 lm/W). Owing to its poor light yield, this type of lamp is being replaced more and more by modern discharge lamps in the domain of street lighting, so that the incandescent lamp is at present practically only used in residential areas, isolated places or on promenades.

In choosing lighting fittings, a distinction has to be drawn between two very different types of fitting. These are, on the one hand, lamp fittings with reflectors, so that the light can be directed, and on the other hand those where the light is screened by diffusers. On main roads with through traffic, practically only continuous lighting, as uniform as possible, is installed. For this purpose, it is as a rule as well to use lamp fittings provided with reflectors to permit of the asymmetric distribution of the light along the axis of the road. In many cases, two lamps are installed in the reflectors, or the latter are formed as double reflectors. This measure makes it possible to reduce the level of lighting during the night when there is little traffic about, without uniformity suffering thereby. Another economical system consists, for instance, of switching certain mercury vapour lamps (radium) to a lower electrical output.

For second class roads where local traffic predominates, on the other hand, it is as well to use fittings for orientated lighting, having an angle of radiation of 200° to 250°. These lamp fittings are generally set up at fairly long intervals at intersections, road forks etc., and enable the pedestrian to find his way at a great distance. To the driver of a motor vehicle, the dot of light visible from afar represents a valuable indication of possible dangers. At the present moment, the diffuser of these lights is generally opaline perspex. Fittings provided with reflectors are not desirable for this form of public lighting.

Establishment of projects

The general recommendations for public lighting, revised by the Swiss Lighting Committee and published recently by the Swiss Electricians Association, act as the basis and directives for planning road lighting schemes. They contain all the necessary technical data about sources of light, fittings, the arrangement and intensity required for the lighting points, according to the width of the road or the type of square, and the density of the traffic. They moreover provide invaluable information as to the way in which light should be measured. The reminder is given here that the determination of the lighting figures with the aid of a lux-meter only allows a general check of the installation under examination. Indeed, a final judgment about road lighting can only be furnished if allowance is always made for the determining factors, viz. the brightness of the illuminated highway and the fittings, and the subjective impression.

Besides technical requirements, modern road lighting must also provide for operating and aesthetic questions. Likewise, considerations of an economic order are far from coming last. A distinction must be drawn between the cost of an installation and the annual expense. The cost of the installation represents all the expenditure on the fittings, auxiliary apparatus, lamps, brackets or suspensions, also the work of laying cables or overhead wires and finally the assembly of the installation. The annual outlay consists of expense represented by outlay on capital, operation, maintenance, and cost of power.

Unfortunately, the cost of the installation, likewise the operation and maintenance of the modern street lighting to be set up according to the current directives, sometimes leads to certain economies being made, which may even reduce the value of the installation. Endeavours are made primarily to cut expenditure by spacing out the lighting points more or by using lamps of lower consumption in the fittings. Those concerned must be warned against such experiments, which enable a saving of 10 to 15 per cent being made.

Lighting of Motorways

At present, specialists are devoting particular attention to the lighting of future express highways and motorways. According to the directives of the Swiss Federal Office for Roads and Embankments, express highways that generally pass through built-up areas should be fitted with modern lighting. Nevertheless, for reasons of a financial nature, the lighting of motorways is not at present being envisaged. It is nevertheless of importance to examine in each case the lighting of the so-called interchanges of express highways, as well as certain nerve centres, such as forks, bridges and, above all, tunnels of any length.

This article is based on one written for Etudes Routières, to whom acknowledgment for permission to publish is made.

A.P.L.E. CONFERENCE

THE Annual Conference of the Association of Public Lighting Engineers will be held at Scarborough October 3-6, 1961. The Spa will be the Conference Hall and Headquarters where an exhibition of street lighting apparatus and equipment will be mounted, while an outdoor display of lamp columns and mobile equipment will be on the Spa Approach.

The Conference will be opened by the Mayor of Scarborough at 10 a.m. on October 3 and Mr. E. C. Lennox, M.I.E.E., F.I.E.S., will be inducted as President, followed by the opening of the exhibition. A Civic Reception will be given on the same evening and the Annual Luncheon the next day. The President's Reception will be on the evening of October 5.

The preliminary programme of papers to be presented is as follows:

October 3. New Lamps—or Old? H. Hewitt, M.I.E.E., F.I.E.S.

October 4. Open Forum on matters relating to Street Lighting. (*A selected platform party will be available to deal with questions.*)

October 5. Some Social and Economic Aspects of Street Lighting, E. B. Sawyer, F.I.E.S.
Colour is No Bar, J. T. Grundy, F.I.E.S. and G. K. Lambert, B.Sc. (Eng.), A.M.I. Mech.E., A.M.I.E.E.

October 6. Local Authorities and Street Lighting—Overall Considerations, D. Clark, Dip. M.I.E.S.

TEC551 *for further information*

A FEW BAGS OF CIMENT FONDU

Concrete made with Ciment Fondu is ready for use 12 to 15 hours after placing. In 24 hours, it is *stronger* than ordinary concrete *90 days old*. Ciment Fondu is equally suitable for speedy Floor Repairs and Renewals, Trench reinstatements, Steps, Sewerage and Drainage work, etc. Send for a copy of 32-page Booklet "The Cement for Industry".

Speed the traffic and reduce your maintenance costs

Single line traffic for more than 24 hours is archaic.

THE CEMENT FOR INDUSTRY

CIMENT FONDU
Regd Trade Mark
ALUMINOUS CEMENT

FOR SPEED • STRENGTH RESISTANCE REFRACTORINESS

LAFARGE ALUMINOUS CEMENT COMPANY LIMITED • 73 BROOK STREET, LONDON, W.1 • Tel: MAYfair 8546

AP 122

INDUSTRIAL NEWS and INFORMATION

PREPARATIONS for the building of the superstructure of the Forth Road Bridge, started early in 1960, are now well under way. The Forth Road Bridge Joint Board awarded the contract to the A.C.D. Bridge Company, a partnership formed by three British firms—The Sir William Arrol & Co. Ltd., the original Forth (Railway) Bridge builders; Cleveland Bridge & Engineering Co. Ltd., builders of the Howrah Bridge in India; and Messrs. Dorman Long (Bridge & Engineering) Ltd., who built the Sydney Harbour Bridge, Australia. The consulting engineers are Messrs. Mott Hay & Anderson and Freeman, Fox & Partners. With its main span of 3,300 ft. the new bridge will rank as the greatest single span in Europe and the fourth longest in the world. When complete the bridge will be almost 1¼ miles in length and 84 ft. wide, it will have two 24 ft. carriageways, a cycle track 9 ft. wide and a foot-walk 6 ft. wide.

Pye Handi-Rangers will be used during the construction of the main cables from which the roadway of the bridge will be suspended. They will enable instructions to be passed to, and between, men working by day and night in isolated positions along the temporary rope footbridges, 1¼ miles long and 500 ft. above the river. This will include controlling the winches up to half a mile away from the load being moved and co-ordinating the observations of a large number of engineers in precisely setting the strands of the cable. Throughout the bridge construction radio communication will also be maintained with boats in the river below.

T.E.C. 208 for further details

Changes in Shell-Mex and B.P. Ltd.

Mr. C. M. Vignoles, C.B.E., Managing Director of Shell-Mex and B.P. Ltd., retired on June 30 and has been succeeded by Mr. J. E. H. Davies.

Mr. Davies, who is 45, joined Anglo-Iranian Oil Company—now The British Petroleum Co. Ltd.—in 1946, and since 1956 he has been a General Manager. He was elected to the Board of Shell-Mex and B.P. Ltd. in 1956 and to the Board of BP Trading Ltd. in 1960.

Mr. Vignoles, who is 60, has been Managing Director since 1951. He retires after 37 years distinguished service to the oil industry beginning when he joined the Shell group in 1924. Mr. Vignoles played a major part in the organization of oil supplies for the nation during the war. At the time of the Suez Canal crisis in 1956 he became Chairman of the Oil Industry Emergency Committee. He was awarded the C.B.E. in 1957.

L.C.C. Schemes

The three following schemes costing a total of more than £3 million were approved by the L.C.C. at their meeting recently.

About £1 million is to be spent on modernizing the Woolwich Ferry, including the replacing of the landing stages. The new ferry boats are to be end-loading, instead of side-loading as at present, and to facilitate operation the new landing stages will consist of a causeway terminating in a hinged bridge. The south approach is also to be improved by the provision of a roundabout at the junction with Woolwich High Street, with space to accommodate 80 vehicles.

Another £1½ million will be spent on an improvement at Bow Bridge, which crosses the county boundary on the River Lea. A flyover is to be built and a roundabout provided. This scheme presents a number of interesting problems of design and construction. The roundabout will be partly over the River Lea and it will be necessary to put in a temporary bridge during the course of the work and demolish the present bridge. The towpath for the horse-drawn barges on the River Lea will need to be re-routed and great care taken to ensure that the western approach to the flyover will not cause disturbance to the structure of the adjacent Bow Church.

The third scheme is for the reconstruction of the river wall at Millbank. Work will start soon on the widening of Millbank between Atterbury Street and Thorney Street, to a width of 90 ft., taking six lanes of traffic, and it will be necessary to reconstruct part of the river wall farther out into the river. The project has been approved by the Minister of Transport for inclusion in the Council's priority programme of major road improvements. The estimated total cost is £509,350.

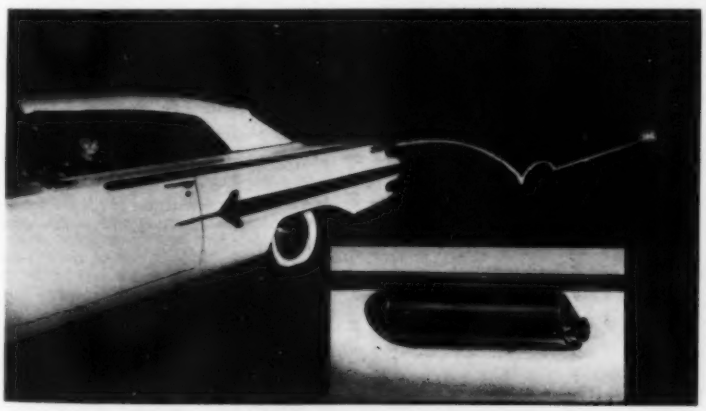
T.E.C. 209 for further details

Flares for Emergency Use

One of the dangers of the high speed motorway is the risk of a puncture or mechanical failure bringing a car to a standstill in a traffic lane. At night there is the risk that following vehicles may crash into the back of the stationary car causing a multi-vehicle pile-up. As an attempt to avoid this danger an emergency flare has been designed consisting of a small chromium plated cylinder, which is fastened beneath the rear bumper or incorporated into the bodywork at the rear of the car. All the driver of the disabled vehicle has to do is to press a button on the dashboard. The flare is then instantly ignited and ejected out on to the highway for a distance of 25 ft. Because of its shape the flare cannot roll off the highway but continues to burn with a red glow which can be seen for a considerable distance. It lasts for a period of about 15 minutes.

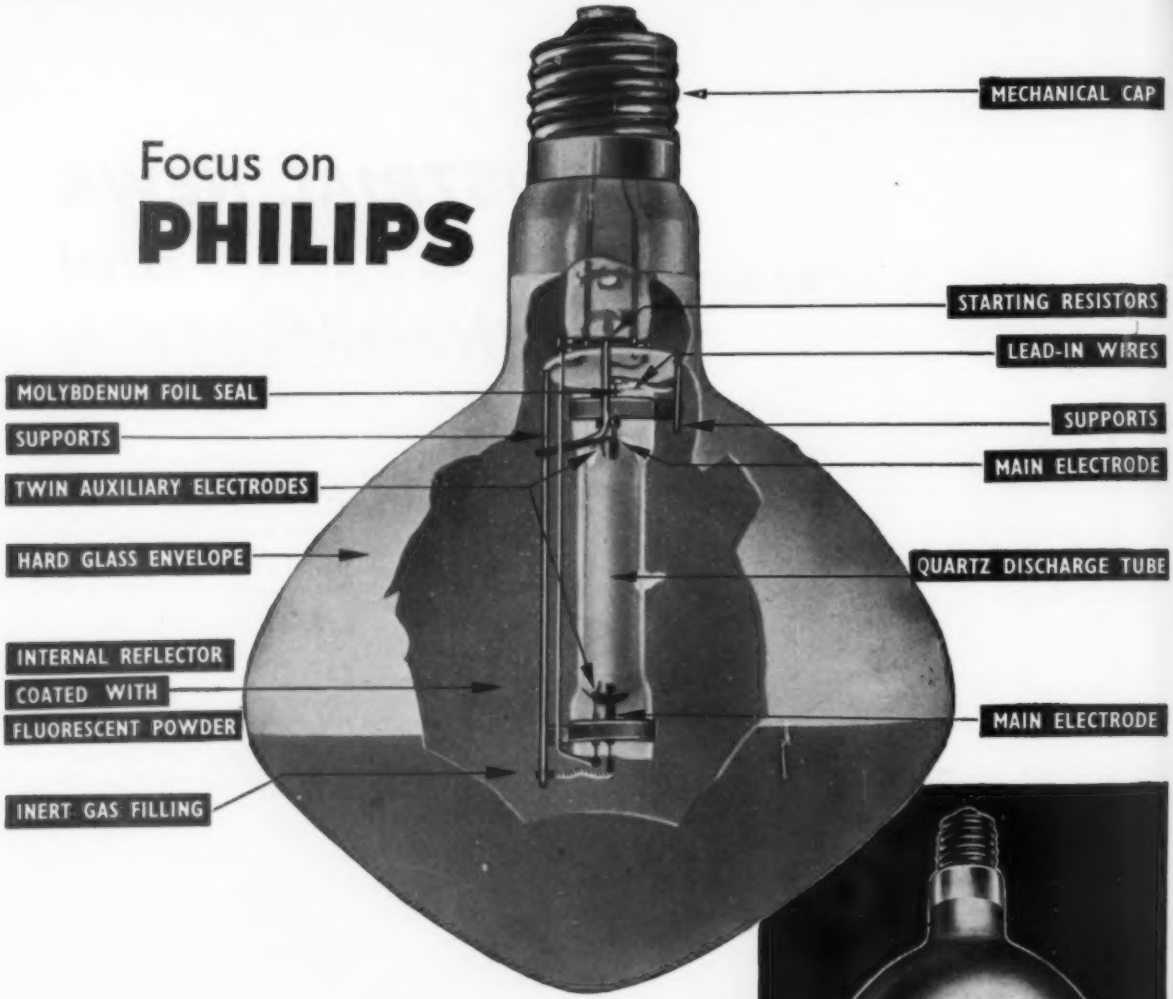
Quite a number of cars in the United States have been equipped with this device and highway patrol personnel find them particularly useful.

T.E.C. 210 for further details



An Emergency Flare in use.

Focus on
PHILIPS



MERCURY FLUORESCENT LAMPS
with Internal Reflector

(Made in Holland)

First in Great Britain with this new class of lamps, available in 250 and 400 watt ratings. All the advantages of Philips Mercury Fluorescent lamps are built in, but the outer envelope forms a highly efficient reflector. The lamp is its own fitting.

The mechanically made high pressure quartz discharge tube is mounted by an exclusive system which defeats light wastage, vibration and reduces the number of working parts. It is sealed in nitrogen and is filled with argon and mercury; special features are twin auxiliary electrodes to ensure reliable ignition even at temperatures as low as −40° C.

An exclusive new capping process screws the glass into the cap without cement. Excellent colour correction and high light output are blended and directed by the internal reflector which ends maintenance problems.

- *Built-in reflector defeats dust and dirt.*
- *Simpler fittings – mechanical protection only.*
- *No voltage grades – 200/250 volts eliminates stock problems.*
- *Universal burning position.*
- *Special phosphors ensure good colour.*
- *Mechanical caps – no cement means no loose caps – ever!*
- *Mechanical manufacture of all components ensure extreme reliability and quality constancy.*

PHILIPS LEAD THE WORLD IN LIGHTING

PHILIPS ELECTRICAL LTD · LAMP & LIGHTING GROUP · CENTURY HOUSE · SHAFTESBURY AVE · LONDON WC2

(LD3306)

Please use the prepaid cards for the Reader Information Service. For further details of items mentioned in this journal, complete and return the card to us.

Tape Recorders in Surveys

In connection with the preparation of a master plan for the redevelopment of the central area of Sutton, a detailed traffic survey has been undertaken jointly by the Borough and County Councils. Saja tape dictation machines were selected for the recording of registration numbers on the six busiest routes, since the sensitivity of this unit's microphone is so versatile that successful recordings can be made in very noisy conditions. A new improved model of the Saja called the Graetz will be available this month. Twelve of these machines were used, again supplied by the Dictation Machine Division of The Tape Recorder Centre Ltd., who assisted with the first recordings made. The machines were plugged into lamp posts and recordings made during selected control periods, providing a simultaneous and accurate record with a considerable saving in manpower. The Tape Recorder Centre Ltd. specialize in the supply of recording equipment for all purposes and are always very happy to advise Councils on tape and dictating applications.

T.E.C. 211 for further details

Contract for Tarmac

A spokesman for the Tarmac Group of Companies gave details recently of a new contract awarded by Cheshire County Council to Tarmac Civil Engineering Ltd., for the construction of the major Cheshire section of the Birmingham-Preston motorway. The contract, valued at approximately £8,600,000, will provide over 15 miles of dual three-lane motorway with hard shoulders, extending from the southern approach to Thelwall Viaduct, spanning the Mersey and Manchester Ship Canal just east of Warrington, to a point just west of Holmes Chapel. Included in the Contract will be the diversion of side roads, and the construction of three two-level interchanges as follows:

(1) Lymm interchange (A50) on the Warrington to Knutsford road.
(2) Manchester Road interchange (A556) on the Northwich to Manchester road.
(3) Holmes Chapel interchange (A54) on the Middlewich to Holmes Chapel road.

Other works include the construction of 36 bridges. These will consist of a combination of pre-cast and in situ concrete slab decks. One of the bridges will span the River Dane, while another will form a viaduct over the railway and road at Lymm. A further bridge will carry the motorway over the Bridgewater Canal. Due to the nature of the ground some of the bridges will be founded on cylinder piles bored to depths exceeding 70 ft. The motorway

A Saja Tape Recorder.

construction will consist of hot rolled asphalt with 10 in. cement bound granular base.

Scott & Wilson, Kilpatrick & Partners of London, are consulting engineers for the bridges, and the contract is scheduled for completion in 27 months.

Self-Loading Dumper

A self-loading dumper was announced and shown for the first time at the Crystal Palace Exhibition in June, by Construction Machinery Ltd. Something quite new to the British market, it is a machine of almost unlimited applications and is covered by worldwide patents. During the past few years it has been fully proved on the West German market.

The method of operation is simple. The lift arms supporting the shovel are positioned on the outside of the body, with the shovel working beyond the tailboard. To load, the shovel is lowered, filled in the usual way and lifted so that the full load can be tipped into the rear portion of the body, subsequent loads being brought progressively towards the front, until the body is filled. This outstanding advantage of loading along the central axis of the body needs no stressing. The operator sits in a comfortable swivel seat and has duplicate controls. Thus he can load, swivel round and drive away without turning the vehicle; the same, of course, applies after tipping. Not only does this feature save time, but is invaluable in confined spaces. The Wakefield Dumper is a compact machine with 9 ft. 3 in. wheelbase, powered by a Leyland AU350 diesel engine developing 100 h.p. at 2,200 r.p.m., and fitted with a 16 in. single dry plate clutch. There is constant mesh transmission with five high and five low gears, giving a total of 10 speeds forward and ten reverse speeds, from 2.13 m.p.h. to 32.6 m.p.h. The loading bucket has a nominal capacity of 1 cu. yd. and is of substantial construction, with welded cutting strip and nine integral teeth. The lift arms are of heavy box section type. The 5½ cu. yd. capacity body is all-steel, stoutly reinforced.

T.E.C. 212 for further details

Woolwich Parking Meters

The parking meters installed at Woolwich in connection with the Woolwich Parking Scheme, referred to in the Parking Section of the June issue, are Karpark Unimatic Meters, similar to those installed at St. Pancras and Aylesbury and are to be installed at Croydon.

T.E.C. 213 for further details

BACK NUMBERS

Requests are frequently received for back issues of *Traffic Engineering & Control*, and because of expense involved, including search, packing and dispatch, it has been decided to charge 5s. for 1960 numbers and 4s. for those of 1961. This does not apply to retrospective subscribers for the current year.

The May and December 1960 issues are out of print and if any readers have got spare copies it would be appreciated if they could return them to Printerhall Ltd., 34/40 Ludgate Hill, London, E.C.4.

The Wakefield Self-Loading Dumper.

STOP parking control problems with

PARCOA

AUTOMATIC PARKING SYSTEMS

PARCOA automatic parking systems provide the complete mechanical answer to trouble-free control. This well-proven system can be relied on to handle traffic smoothly, safely, efficiently and economically in *any* parking facility.

THE MAIN ADVANTAGES

CUTS OPERATING COSTS. Eliminates Payroll Expense, Shift Working and Revenue Losses. Avoids problems of labour procurement and supervision. Amortised over a few years—costs much less than labour.

CONTROLLED CAPACITY. With PARCOA there can be no over-crowding. No customers looking for spaces that are not there.

FLEXIBLE OPERATION. Your choice of exclusive card-keys, coins, tokens, automatic ticket-dispensers or any combination to fit your specific needs.

PROTECTS REVENUE. Assures 100% collection, and includes self-locking cash vault with four-way lock.

PARCOA—THE RIGHT CONTROL FOR YOUR PARTICULAR NEED . . .

Your enquiries are invited. Our advisory service can help you through all the stages of developing efficient, smooth running and economically sound off-street parking arrangements.

Exclusive U.K. Distributors

PARKING DEVELOPMENTS LIMITED
2-4 CRANMER ROAD, LONDON, S.W.9. *Tel. RELiance 5192*

Have you the highest-known Safety Factor built into your traffic markings?

CATALITE* IS WHAT YOU NEED!

* PREMIXED REFLECTIVE TRAFFIC PAINT

- CATALITE is a long-wearing, highly reflective plasticised marking paint in which glass beads (ballotini) are incorporated during manufacture. This provides a uniform bead content throughout the line—laterally, longitudinally and in depth.
- The premixed ballotini strengthen the marking film, ensuring longer life, and reinforce the normal bead overlay.
- Any crushing, dislodgment or scattering by wind of the bead overlay on a CATALITE line is less important because the reservoir of beads at lower levels of the film is sufficient to maintain high reflectivity.
- The constant predetermined premix bead content is independent of spray operation or machine design.
- Distribution of beads in depth is independent of ambient temperature.
- CATALITE, overlayed with beads, gives a line which maintains its visibility as it ages.

MARKING MACHINES BTM in conjunction with Messrs. Aerostyle Ltd., London, N.W.10, can offer the latest machines for any and every marking job great or small. Write today for full details.

BTM

BERGER TRAFFIC MARKINGS LTD
18 Queensberry Place, Sth. Kensington,
London, S.W.7. KENsington 5345